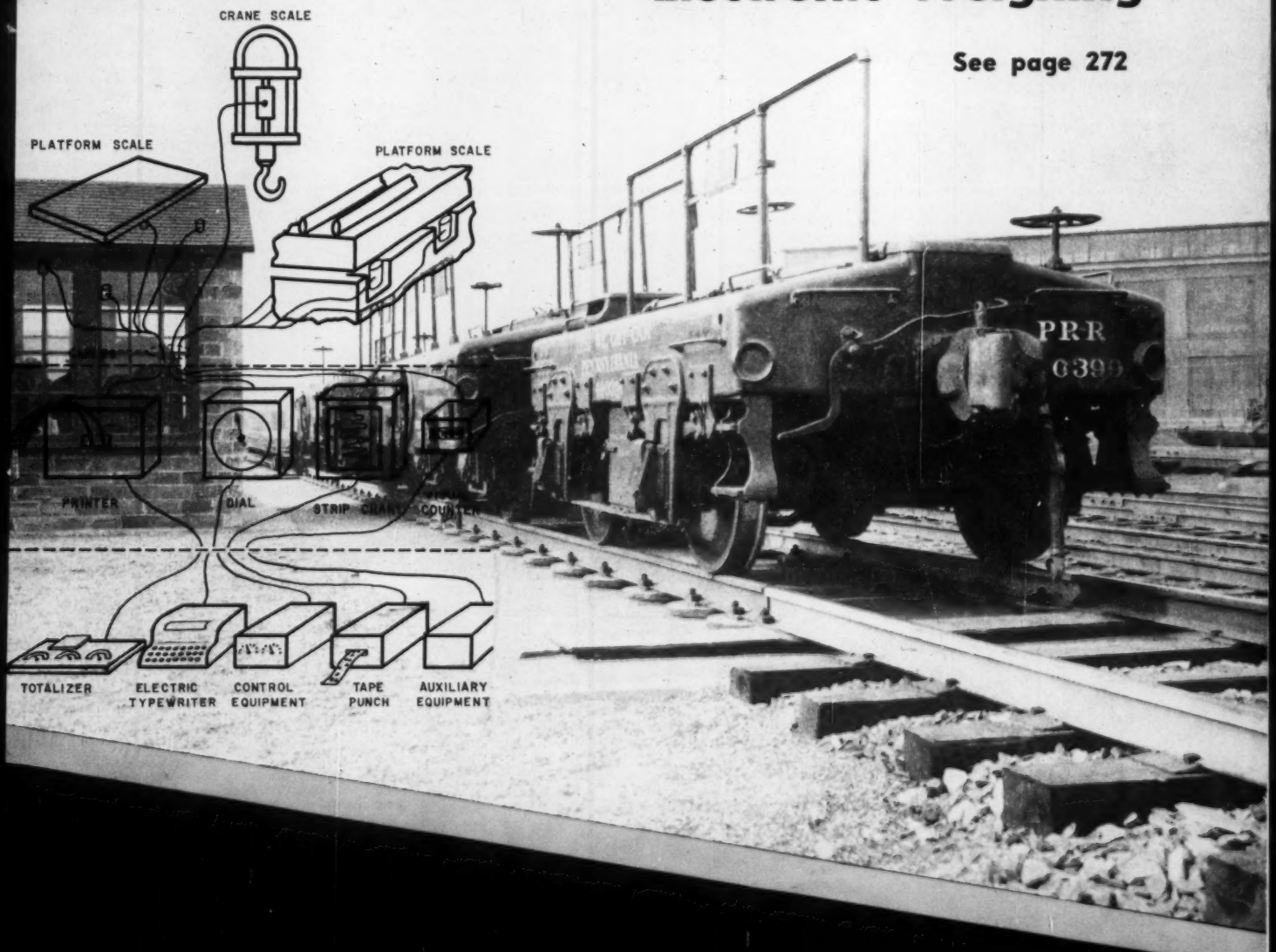
INSTRUMENTS and AUTOMATION

Electronic Weighing

See page 272

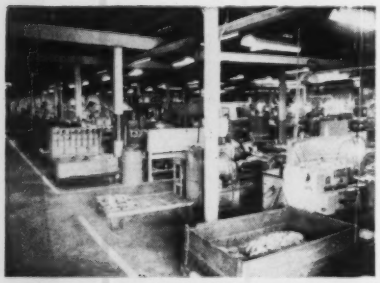


Inner valves are machined on duplicating lathes to exacting standards. In this photo, master contour plate on lathe at (A) automatically duplicates the exact contour desired at (B) to form the inner valve.

Precision parts on BS&B Controls are manufactured to close tolerances. This lathe operator "mikes" inner valve for a final tolerance of .001". Other parts require tolerances of as little as 3/10,000"

In Automatic Controls,

BS&B Means..."Trouble-Free"!



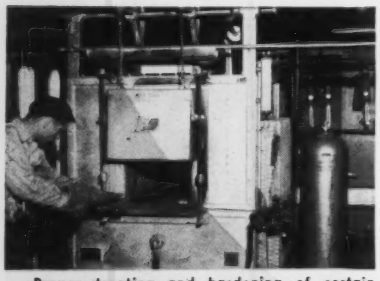
Ample production facilities and stocks of material assure prompt deliveries on all standard items in the BS&B Controls line.

Whenever you buy an automatic control, you look for the finest and most dependable one you can find for the job from the standpoint of quality, precision, long life and *"freedom from trouble."*

Freedom from trouble is especially important, because once a control is installed in the line, any "down-time" caused by its faulty operation becomes very expensive—usually many times more expensive than the entire cost of the control itself.

That's why it *always pays* to specify and buy BS&B Automatic Controls! Because of their superior quality and their long trouble-free performance, they'll *pay for themselves* in almost no time!

A Sinusoidal waveform apparatus is used to check the accuracy and performance of a BS&B Type 1440 Pressure Control Pilot.



Proper treating and hardening of certain component parts of BS&B Controls in one of these precisely controlled electric annealing furnaces is just one of the important manufacturing operations which assures their high quality and long trouble-free service.

Every BS&B Control must pass rigorous operating tests in our modern hydraulic testing and experimental laboratory. In this view, valves in the line are under test pressures from hydraulic pumps in the foreground. Operator checks readings on the control panel for valve performance.

EFFICIENCY
OVER 60 YEARS
BS&B
RELIABILITY

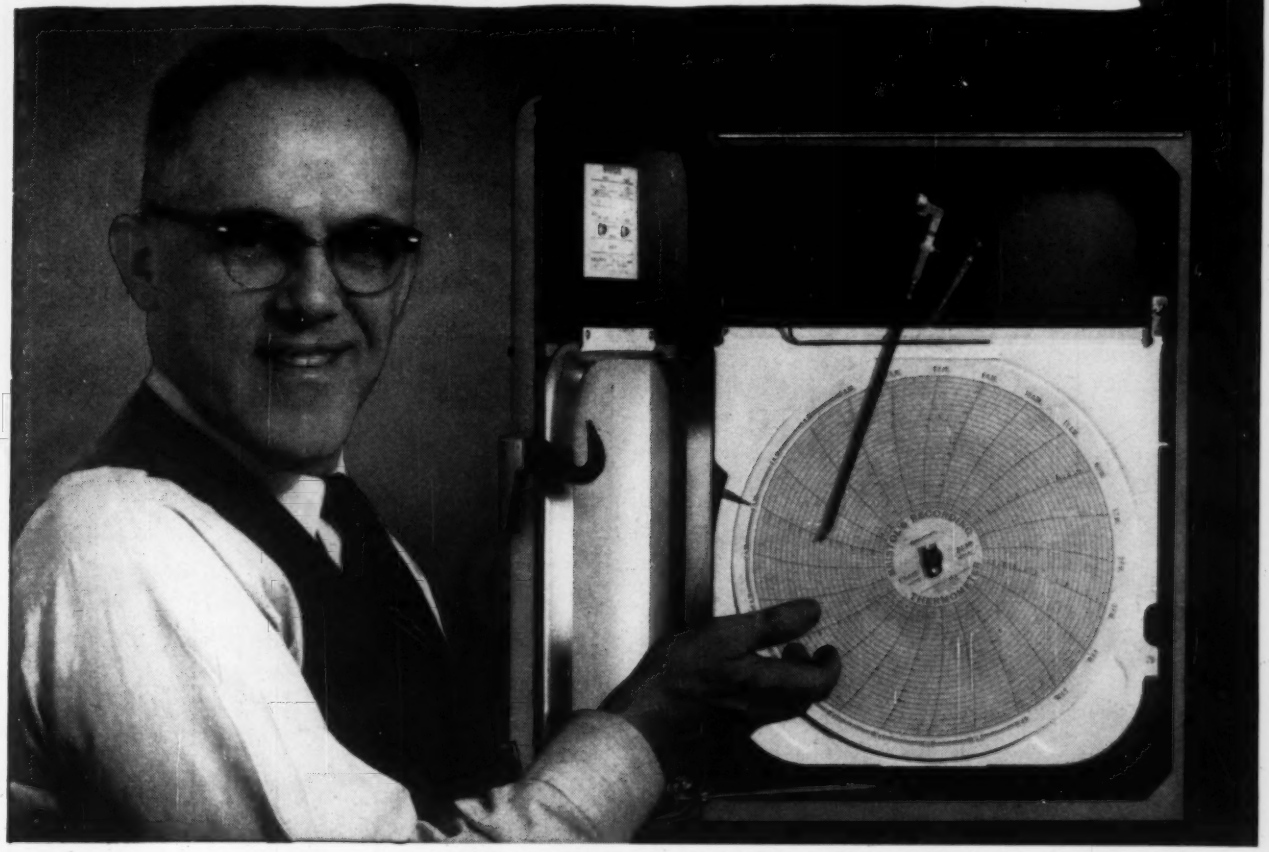
BLACK, SIVALLS & BRYSON, INC.

84 Sales Centers — Controls Division, Dept. 4-V2 — 40 Stocking Points

7500 East 12th Street, Kansas City 26, Missouri

For more information circle 1 on inquiry card.

WHAT'S NEW AT BRISTOL . . . . WHAT'S NEW AT BRISTOL

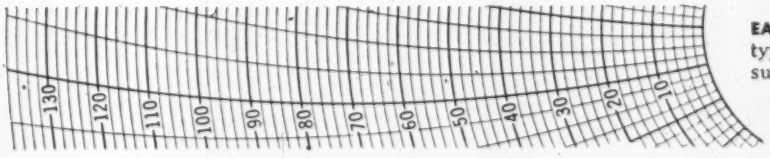


HIGH-SPEED RESPONSE AND ACCURACY are characteristic of the new Bristol Dual-Filled Vapor Pressure Thermometers. Unlike conventional vapor pressure thermometers, the Bristol units can be read with equal ease and accuracy throughout the entire measured range.

Another Bristol first — Dual-filled Vapor Pressure Thermometer with uniform linear scale

• These new instruments are the latest example of Bristol's continuing leadership in the field of industrial thermometry. They represent the first really important advance in filled-system thermometer design in more than 25 years. With this new development, all the valuable features of the vapor pressure system are retained. In addition to the linear scale, the elimination of ambient temperature effects makes new standards of accuracy possible.

Get the complete story on these rugged, precision instruments. Write for free 48-page bulletin T840. It will tell you all about typical installations, ranges, charts, bulbs and tubing. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.



EASY-TO-READ. This full-size section of a typical Bristol Dual-filled Vapor Pressure Thermometer chart shows the extreme clarity and definition of its uniform linear scale.

4.12

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **2** on inquiry card.

designed and fabricated for your special needs!

FALSTROM—custom metal fabricators since 1870—offer America's most up-to-date facilities for the manufacture of large or small parts in sheet steel, aluminum, copper, brass and other alloys to closest tolerances . . . on long or short runs. A to Z fabrication under one roof is another advantage that saves you costs and avoids delays.

FALSTROM makes all kinds of instrument panels, graphic panels, cabinets, chassis, cubicles, consoles and metal fabricated parts for all industrial purposes. Consult Falstrom for custom contract manufacturing at practical unit cost. Send us your blueprints for quotation or ask about our standard designs. **Write for Bulletin 143-A.**

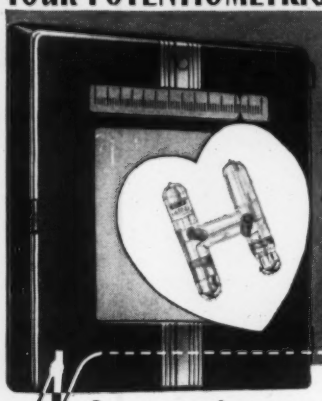
Falstrom means it's that much better!

FALSTROM co.

92 Falstrom Court • Passaic, New Jersey

For more information circle **3** on inquiry card.

YOUR POTENTIOMETRIC INSTRUMENTS HAVE A HEART TOO!



NO matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

The "heart" of most such instruments for the past quarter century has been the Eplab Standard Cell. It is a "yardstick" for translation of voltage to temperature or pH. The first American commercial cell of its type, constantly improved by research, it is "as standard as sterling".

Get ACCURATE temperature or pH control with potentiometers and make sure the standard cells are EPLAB.

The Eppley Laboratory, Inc. 2 Sheffield Ave., Newport, R. I.

EPLAB *Standard* CELLS
FOR POTENTIOMETRIC INSTRUMENTS
"As Standard as Sterling"

For more information circle **4** on inquiry card.

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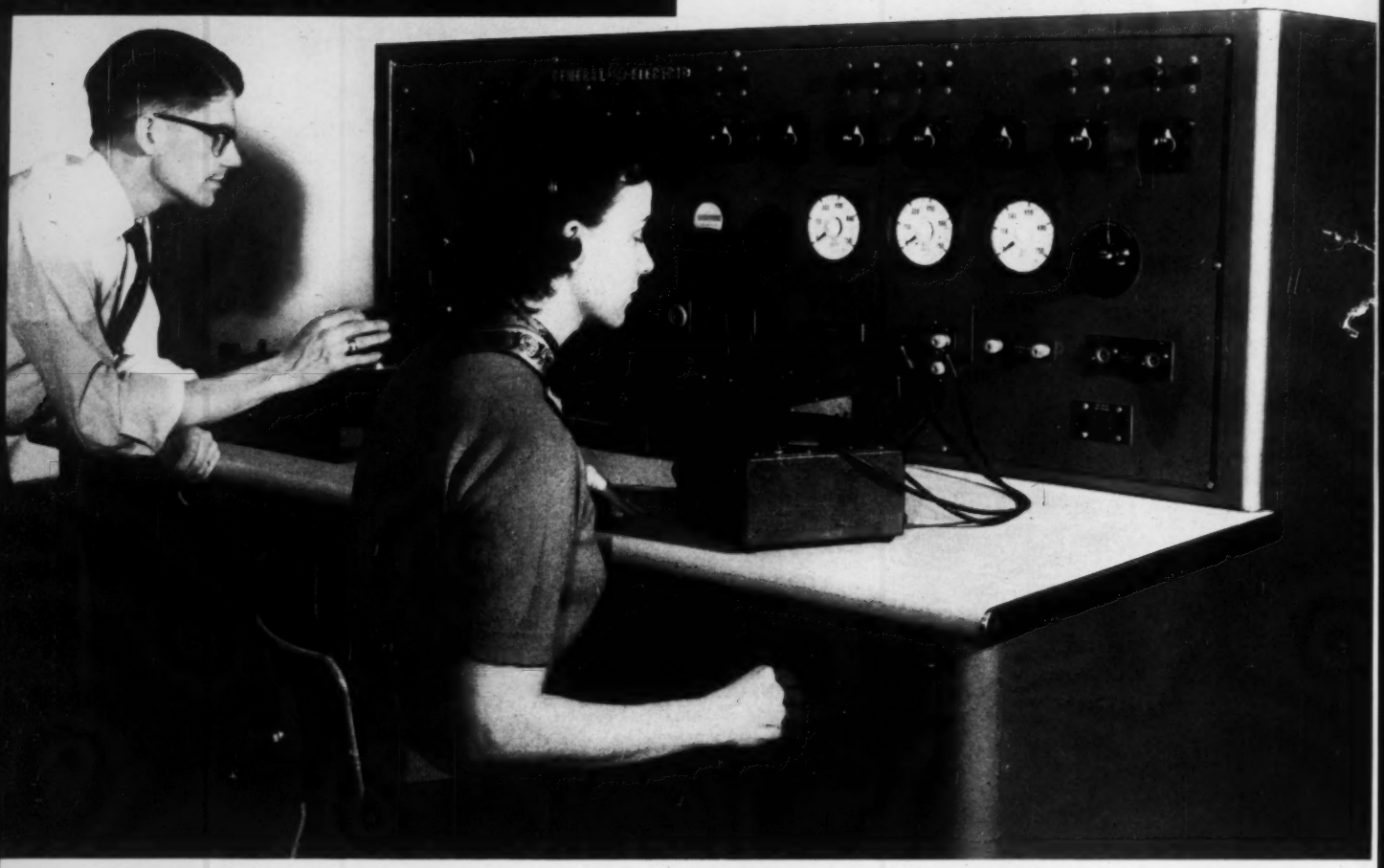
Developments in Laboratory Instruments



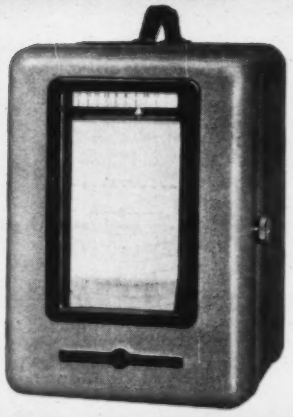
TO SAVE VALUABLE MAN-HOURS, G-E CONSOLE IS FUNCTIONALLY DESIGNED FOR SIMPLE OPERATION; FEATURES EASY-TO-REACH CONTROLS.

News About Other General Electric Instruments for Precision Measurement in the Laboratory

INSTANTANEOUS VAPOR DETECTOR

FOR HEALTH MONITORING of mercury vapor and certain other toxic vapors, this portable General Electric instrument pinpoints contaminated areas; can be used wherever 115-v., 60-cycle power is available. $495.00.*

PHOTOELECTRIC RECORDER



RECORDING RAPIDLY CHANGING PHENOMENA with minimum load on measured circuit, recorder is available with sensitivity as low as 1 ua full scale. Response times as low as 1/5 second. $700.00.*

*Manufacturer's suggested retail price.

For more information circle **5** on inquiry card.

Minimize Calibration Time With Versatile, Easy-to-use General Electric Instrument Standardization Console

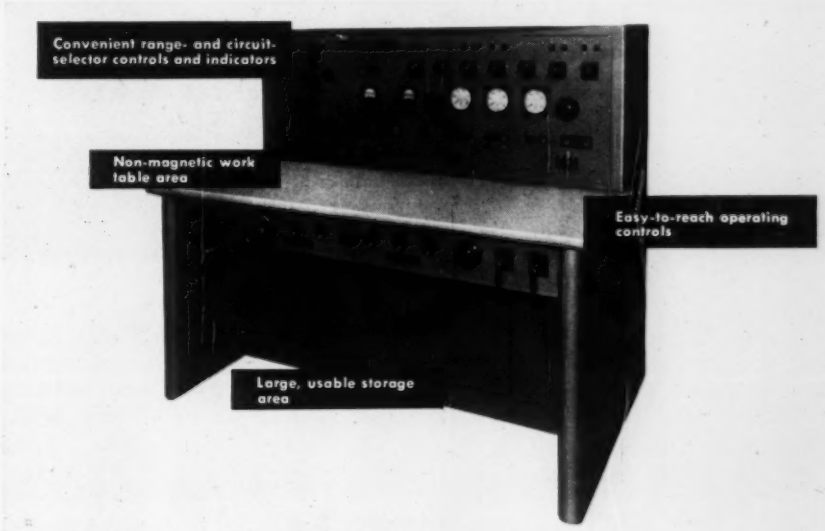
PROVIDES REGULATED POWER SUPPLIES FOR PRECISE INSTRUMENT CALIBRATION

The General Electric instrument standardization console provides regulated power supplies for precise calibration of a wide range of electric instruments.

HIGHLY ACCURATE, the console provides facilities for referring both d-c and a-c measurements to a standard cell, or to a laboratory standard instrument.

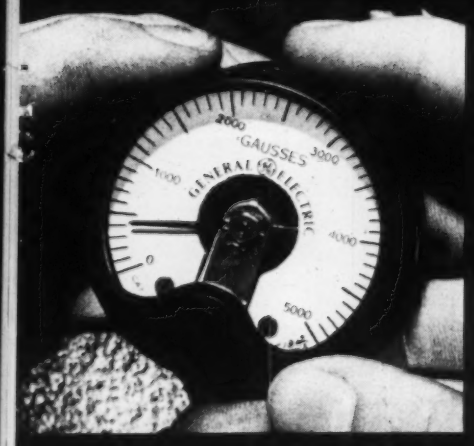
WIDE RANGES of a-c and d-c power supplied by the console facilitate the calibration of voltmeters, ammeters, frequency meters, and many others. Both a-c and d-c standardization tests can be made up to 750 volts, or 150 amperes; with low-distorted a-c frequencies from 50 to 3000 cycles.

FOR FURTHER INFORMATION about the General Electric instrument standardization console, contact your nearest G-E representative, or clip coupon below for Bulletin GEA-6005.


Convenient range- and circuit-selector controls and indicators
Non-magnetic work table area
Easy-to-reach operating controls
Large, usable storage area

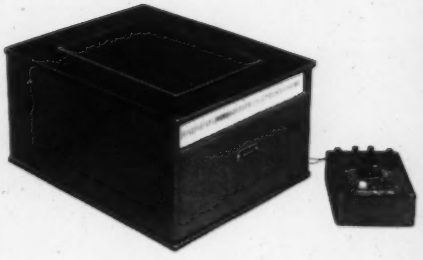
HIGHLY VERSATILE, the General Electric console has necessary switches, busses and indicators for calibration of a-c and d-c laboratory-standard, portable, small-panel, switchboard, and recording instruments. Requires only normal 115-v, 60-cycle source.

GAUSSMETER



CONVENIENT, POCKET-SIZE G-E meter facilitates checks of flux density and direction in magnetic gaps. Ideal for use in small or congested areas. Price including reference magnet and case, $67.10.*

INDICATING FLUXMETER



HIGH ACCURACY AND SENSITIVITY combine to provide precise magnetic measurement. Accuracy is ±1% of full-scale deflection; sensitivity is as high as 1 millimeter deflection per 100 flux lines. Price is $278.50.*

SECTION C 605-76
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, N. Y.

Please send me the following bulletins:

- ☐ Instrument Standardization Console (GEA-6005)
- ☐ Instantaneous Vapor Detector (GEC-1275)
- ☐ Photoelectric Recorder (GEC-245)
- ☐ Equipment for Measuring Magnetic Properties (GEC-777)

NAME .....

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CITY ..... ZONE ..... STATE .....

GENERAL ELECTRIC

For more information circle **5** on inquiry card.

2 Stock Answers for

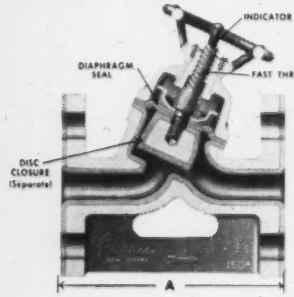
Farris X-V Series

This versatile, dependable, economically-priced hand valve is equally at home in corrosion, abrasion, vacuum or general service—wherever positive action is needed. The X-V Series disc—for positive closure—and diaphragm—for positive sealing—work independently, with only the disc exposed to pressure in the closed position, substantially increasing diaphragm life, lowering torque and providing unsurpassed vacuum service . . . No other valve does such a complete job at so little cost!

Write for Bulletin FL-154

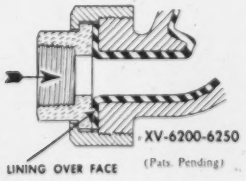
DISC for positive closure

DIAPHRAGM for positive sealing



NEW

Corrosion Resistant Union Ends



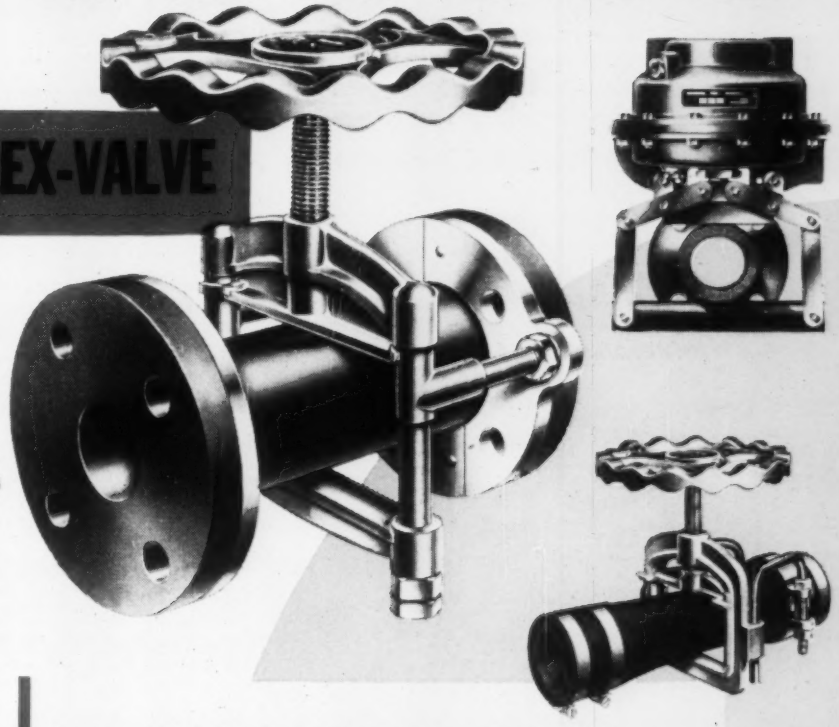
For more information circle **6** on inquiry card.

X-V Series Design Features

- Realistically-Priced for Low-Cost Service
- 50% Greater Capacity than Similar Type Valves
- Only Disc Area Exposed to High Vacuum in Closed Position
- No Packing Gland to Leak. Mechanism Not Exposed
- Low Hand-Wheel Torque... Easy to Operate
- Available in Lined or Unlined Models...With Corrosion Resistant Union Ends.

Tough Valve Problems

Farris Pinch-type FLEX-VALVE



No other valve controls the flow of hard-to-handle corrosive and abrasive materials with the efficiency and reliability of the Farris Pinch-Type FLEX-VALVE . . . because FLEX-VALVE cannot plug! This is the simplest valve made—only two components—employing the fundamental principle of pinching off the rugged, flexible valve body. Case histories show batteries of these valves in severe service for more than 20 years—and still going strong!

For complete information write for Catalog FL-382

YOUR MONEY BACK

IF IT PLUGS!

Flex-Valve's Exclusive Advantages

- Will Outwear Any Metal Valve in Abrasive Service
- Full Pipe Capacity
- Maintenance Free
- Bubble Air-Tight
- Low Replacement Cost
- No Obstructions, Pockets or Internal Parts
- Available in Rubber, Neoprene, Butyl, Buna-N, Buna-S, Food Stock and Special Compounds.
- Air or Hand-operated Types

Farris

There is no compromise with experience!
There is only one FLEX-VALVE

FLEXIBLE VALVE CORPORATION

415 COMMERCIAL AVENUE, PALISADES PARK, NEW JERSEY

affiliates: FARRIS ENGINEERING CORP. • FARRIS STACON CORP.
FARRIS HYDROSEAL CORP. • FARRIS HYDROTORQUE CORP. • FARRIS PICKERING GOVERNOR CO.

For more information circle 6 on inquiry card.

one simple oscillograph . . .

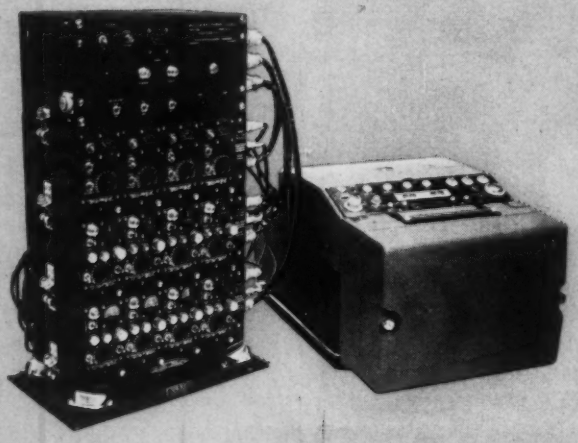
or an entire instrumentation system . . .

Here's the COMPLETE

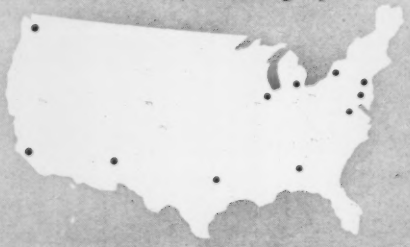
PRICE IS NO CRITERION . . . buy CEC's most economical oscillograph . . . or buy an elaborate *system*, capable of the most complex measurements. Either way, you share in our 18 years of data-processing experience . . . broadest in the field. The same quality that has made CEC the world standard for data recording is found in the least as well as the most expensive instruments.

INTERCHANGEABILITY . . . COMPATIBILITY. These are hallmarks of CEC's entire line. Use the instruments individually, or combine them to meet almost any technical or budget consideration. Whether your problem is as simple as measuring spring deflection on a farm-tractor seat or as critical as recording an atomic blast, think first of CEC . . . the *complete* data-recording line.

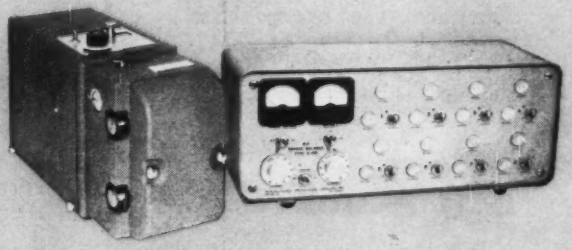
Some combinations possible with CEC's standard, "off-the-shelf" instruments . . .



5-119 OSCILLOGRAPH PLUS AMPLIFIER SYSTEM D . . . The ultimate in analog data-recording versatility. The oscillograph can record up to 50 data traces; the amplifier is usable to 5000 cycles. Shock mounted, rugged, with elaborate safety devices to prevent loss of data, the system is ideal for flight tests, complex wind-tunnel and test stand measurements . . . *any* test where phenomena are both numerous and high-speed.



5-117 OSCILLOGRAPH PLUS 8-108 BRIDGE BALANCE . . . For simpler, low-frequency tests. Small and lightweight, the oscillograph can record up to six traces, uses 70-mm paper. The Bridge Balance allows direct coupling of strain gages or resistive-type pickups to high-sensitivity galvanometers in the oscillograph. Operation is extremely simple, requires little electronic experience.



NATION-WIDE SERVICE. Experienced, factory-trained service engineers stationed at CEC field offices throughout the United States are available for both emergency repairs and regularly scheduled maintenance calls. Complete stocks of spare and replacement parts are maintained in major areas, immediately available in case of emergency. Major repairs or modifications are performed by our Repair Department in Pasadena. The CEC service organization is your assurance of uninterrupted test programs.

For more information circle **7** on inquiry card.

data-recording line

ruggedness
accuracy
dependability...
—insist on all three!

use them together...
use them separately...
use them in any combination

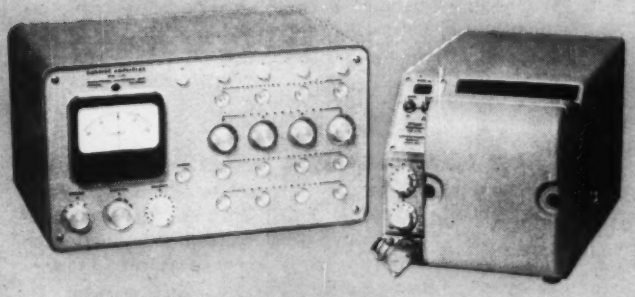
You can use *any* CEC oscillograph—from the economical, simple 5-117 to the advanced-design 5-119—with *any* CEC amplifier or bridge balance. All are compatible... no modifications are required. Keystone of this flexibility, which makes it possible to change or expand instrumentation at any time, is the 7-300 Galvanometer. Used in all CEC oscillographs, it is the "design nucleus" of all CEC analog data-processing instruments.

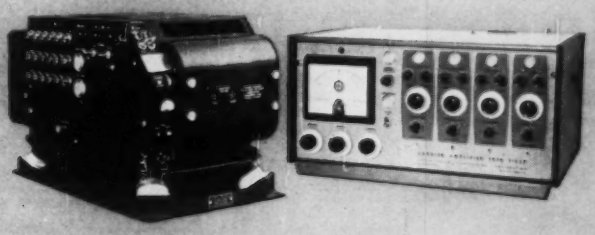
The 7-300 Galvanometer, used in all Consolidated oscillographs. Extremely stable... rugged... available in a wide range of characteristics. It brings laboratory accuracy to on-the-spot recording.

5-116 OSCILLOGRAPH PLUS 1-118 CARRIER AMPLIFIER... An ideal general-utility system. The 4-channel amplifier is usable for phenomena up to 600 cps with almost any type of transducer requiring external excitation. The oscillograph produces a 5-inch record at speeds from ¼" to 100" per second, available with either 9 or 14 traces, depending upon the model.

5-114 OSCILLOGRAPH PLUS 1-127 CARRIER AMPLIFIER... World's most widely used recording oscillograph, the 5-114 can be furnished with either 18- or 26-trace capacity...

Special accessories permit recording at chart speeds up to 500" per second. The 4-channel 1-127 Amplifier is usable for phenomena from static conditions to 3000 cycles.





Associated equipment to make these Consolidated instruments and instrument systems even more versatile, more convenient to operate:

OSCILLOGRAM PROCESSOR for rapid, automatic record development

PICKUPS for precision sensing of pressure and vibration

POWER SUPPLIES to permit operation any place, under any conditions

SPECIAL-PURPOSE OSCILLOGRAPHS for recording under difficult conditions of limited space, extreme acceleration, etc.

Consolidated Engineering
Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service Offices Located in: Albuquerque, Atlanta, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, Seattle, Washington, D.C.

Send today for Consolidated's latest general catalog of Data-Processing Instruments. It contains brief descriptions of today's most complete line of measuring and recording instruments. Ask for Bulletin CEC 1301-X12.

For more information circle **7** on inquiry card.

LEWIS

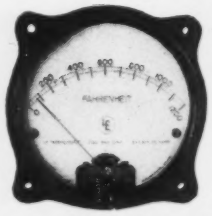
AUTOMOTIVE AND INDUSTRIAL TEMPERATURE MEASURING EQUIPMENT

Sturdy Dependable Indicators —Suitable For Use In Moving Vehicles or For Permanent Installation

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.

MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.

MODEL 62RT4

THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

THERMOCOUPLE LEAD WIRE for connecting thermocouples to the indicators is manufactured in iron-constantan, copper-constantan or chromel-alumel material with standard and special insulation. Use Lewis lead-wire with Lewis instruments and thermocouples for best results.

RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

For more information circle **8** on inquiry card.

Trends...

INSTRUMENTS and AUTOMATION

Instrument industry has grown from $500 million in 1940 to $3.1 billion in 1952, to estimated $4.2 billion in 1954 (according to report by Instruments Publishing Company). INSTRUMENTS & AUTOMATION predicts an instrument-industry growth of about $500 million per year, to total of $12 billion by 1975.

> 1955 will be critical year for automation, says S. J. Sindeband, Teleregister Corp., if (1) past is examined rather than future talked about, (2) fact is established that automation is no substitute for creative brainpower and is unlikely to reduce the total working force, (3) psychological fears are dispelled, and (4) basic simplicity rather than superficial complexity is emphasized.

Financial advisory services are asking investors to look at nation's fastest growing industry—the automation industry. Stocks of instrument companies will benefit from this attention in 1955.

> Industrial production will increase about 43% by 1964, according to several recent economic survey by GE; electrical manufacturing will increase at twice this rate to twice its present level by 1964; all this will be accomplished with only 11% increase in labor force (all that will be available) because of increased use of automation. Note: labor force will increase.

Each new advance in computers opens new avenues of attack on previously unsolvable problems. New Naval Ordnance Research Calculator (NORC) can make weather forecasts for an entire hemisphere up to 60 days in advance; 24-hour forecasts can be made in minutes.

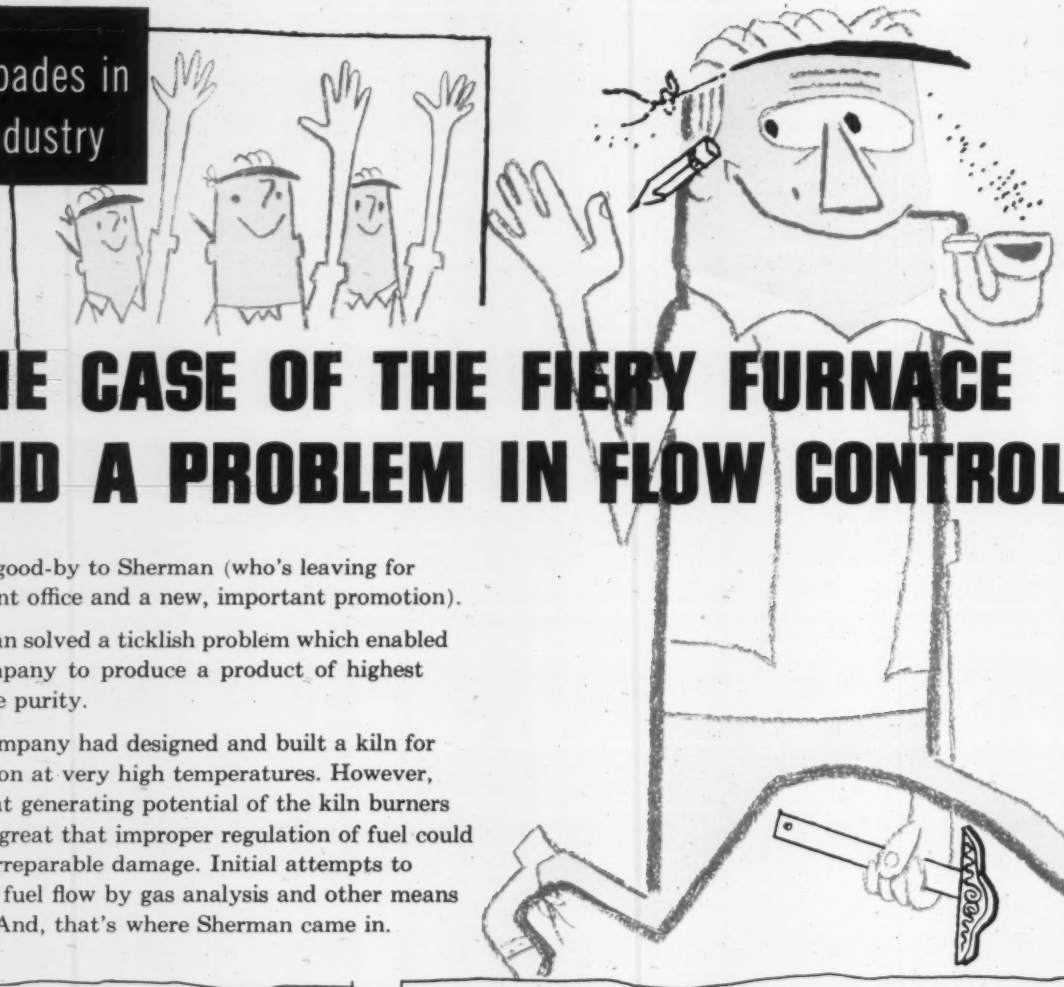
> Computers are giving new perspective to mathematics. Industrial engineers will find it necessary to develop transfer function descriptions of all industrial unit operations for proper analysis of systems to assure optimum operation.

Problems being raised by automation include balancing of production lines, need for rugged and rapid gaging and inspection equipment, faster communication between operators and supervisors, need for more specialists, and need for better cooperation among specialists.

> Will labor demand guaranteed annual wage because of automation? No, says Automation Committee of UAW-CIO in direct answer to this publication. Their reply: "Guaranteed Annual Wage is but one part of a many-sided program for Full Employment; issue was raised before war, before automation was invented as a word; was simply postponed by the war, and will not be used to oppose inevitable progress—but is essential to full employment in the future."

Technical editor is placed in charge of all technical material in one of country's largest technical organizations—Consolidated Engineering Corp. This efficient solution to a serious and growing problem can expand the present small field of technical editing to many times its present size. Use of a technical editor is more efficient than attempting to teach many engineers how to write.

S/K apades in industry



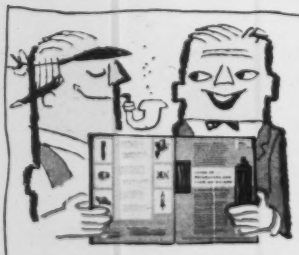
THE CASE OF THE FIERY FURNACE AND A PROBLEM IN FLOW CONTROL

Wave good-by to Sherman (who's leaving for the front office and a new, important promotion).

Sherman solved a ticklish problem which enabled his company to produce a product of highest possible purity.

The company had designed and built a kiln for operation at very high temperatures. However, the heat generating potential of the kiln burners was so great that improper regulation of fuel could cause irreparable damage. Initial attempts to control fuel flow by gas analysis and other means failed. And, that's where Sherman came in.

Sherman remembered reading an article which offered a condensed bulletin on all types of SK Rotameters—accurate, variable area instruments for measuring and controlling fluid rate of flow.



He sent to SK for a copy of Bulletin 18-RA, checked the types of meters described, found a Rotameter to be ideal for the purpose, and called in a specialist—his nearest SK Sales Engineer.

SOLVED THE PROBLEM NEATLY!

An SK Safeguard Rotameter is used to measure the flow of fuel oil to the burners. In operation for some time, the Rotameter has protected the equipment against damage, saved the operator time, and even helped save some fuel by providing simple and accurate rate of flow measurement.

MORAL! *Request a copy of Bulletin 18-RA for your files. Make use of a qualified specialist, your nearest SK Sales Engineer.*

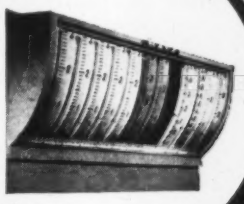
Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS

2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

Jet Apparatus • Heat Transfer Equipment
Strainers • Condensers and Vacuum Pumps
Oil Burning Equipment • Rotameters
Flow Indicators • Radiation Tubes • Valves
Spray Nozzles and Atomizers • Gear Pumps
Desuperheaters

For more information circle 9 on inquiry card.

one of these



W-Gage for large boilers and remote indication

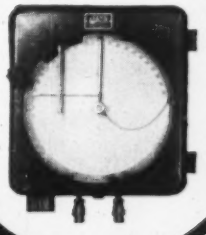
Hays gages

B-Gage for small boilers, combustion testing and air filters

will meet your

FOT-Gage for furnace pressure or fuel flow – air flow indication

LOW PRESSURE



OT-Recorder for draft or pressure

requirements

D-Gage for commercial, institutional boilers and industrial furnaces

Whether you need a draft gage for the largest steam generator, or a small portable gage for spot checking pressure conditions, first or last, it will pay you to talk to Hays, manufacturer of the most complete line of draft and low pressure gages.

Functional in styling, Hays gages have the features instrument men have always asked for—easy to read, accessible and extremely dependable.

The heart of all Hays low pressure gages is a diaphragm housed in cast metal. Diaphragms are easily replaceable in the field.

All Hays gages are guaranteed to withstand at least 100% over range without failure!

Why not talk to the people at Hays about low pressure gages for your applications—or write for complete details: *Bulletin 54-667-8.*

Automatic Combustion Control
Boiler Panels • CO_2 Recorders
Veriflow Meters and Veritrol
Gas Analyzers • Draft Gages
Combustion Test Sets
Electronic Oxygen Recorders
Electronic Flowmeters
Electronic Feed Water Controls
Miniature Remote Indicators

THE hays CORPORATION

MICHIGAN CITY 8, INDIANA

For more information circle **10** on inquiry card.

Light Amplifier

SCHENECTADY, N. Y.—A development of great potential importance for future television, x-ray fluoroscopy, photography, instrumentation, and other fields is the "light amplifier" revealed by scientists from the General Electric Research Laboratory, Schenectady, N. Y.

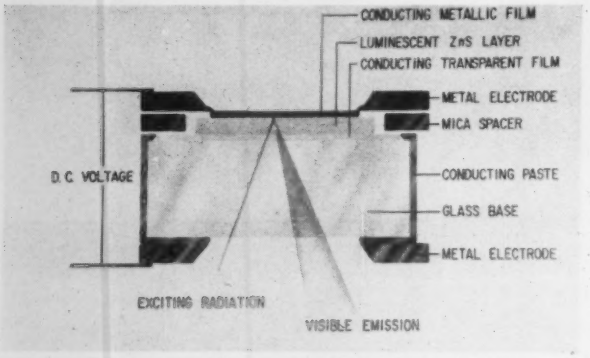


Fig. 1. Cross-section of the new GE light amplifier, a proportional amplifier of great significance. Scene reflected from screen can be controlled in brightness by dc voltage applied across cell.

The light amplifier is essentially a phosphor film (ZnS), which is known to be photoluminescent—that is, an emitter of light when excited by fluorescent light, radioactivity particles, etc. The GE development consists in making the light output of the excited phosphor proportional to the intensity of the incident light, and controllable by an electric field.

An ultraviolet source is used as the projector of the scene upon the screen, and a d-c voltage is applied across the phosphor, as shown in Fig. 1. As the voltage across the screen is raised, the relected scene is increased in brightness, as shown in Fig. 2. The increased brightness of the picture in Fig. 2 is due solely to the light amplification within the screen—neither the light source nor the projecting lens was altered. The contrast remains unchanged, demonstrating the proportional amplification characteristics of the light amplifier.

Fig. 2. Comparison of scenes reflected from screen. Change in brightness was caused solely by electric field applied across cell.

Applications will be limited until many problems are solved—including the small (4-in.) size of the screen (Fig. 3) and the limitations on the type of emitted light. The amplification achieved (ratio of number of photons striking the screen to the number given off) is about ten; higher ratios are believed possible.

Fig. 3. Dr. F. E. Williams (right), head of light-generation studies at GE Research Laboratory, credits D.A. Cusano (left), GE scientist, with creating the light-amplifying phosphor.

Although modulation of photoluminescence by an electric field has been reported previously, this represents the first achievement of true proportional light amplification. Dr. F. E. Williams, head of light-generation studies at the GE Research Laboratory, said that the light-amplifying phosphor was created by D. A. Cusano, young GE scientist.

Nature of Magnetism

PITTSBURGH, PA.—The U. S. Signal Corps have joined the Atomic Energy Commission and the Office of Naval Research in supporting Carnegie Institute of Technology's search into the nature of magnetism.

Professor Jacob E. Goldman, Head of Carnegie's Magnetic Research Laboratory, received $26,500 from the Signal Corps to further his study of fundamental magnetic properties of metals, alloys and salts.

M-H Appoints 42 Field Men

PHILADELPHIA, PA.—Forty-two sales engineers were recently added to the field sales force of Minneapolis-Honeywell Regulator Company's Industrial Division in 25 branch offices located in 23 U.S. cities and 2 Canadian cities, it was announced by J. A. Robinson, field sales manager.

Robinson said that the appointment of the new sales engineers—all graduates of the division's training school in Philadelphia—was in line with the firm's planned growth program designed to meet the increased complexities of marketing in the automation field. He pointed out that despite the fact that 250,000 manufacturing firms use industrial instruments—100,000 plants having installed automatic control equipment since 1940—industry as a whole has probably realized only 10 to 15 percent of the full potential of automatic control.

At the same time Robinson reported that 18 service engineers were also added to the firm's field sales force, taking positions in 12 U.S. cities and 1 Canadian.

300,000-Mc. Generator

STANFORD, CALIF.—Dr. Hans Motz of Stanford University's Microwave Laboratory has invented a gen-

still rugged . . . with NEW and IMPROVED features

See Us At The
New York I.R.E. Show
March 21 to 24
ROOM A
Next Door to First Aid Room

Announcing the new Model 581 Oscillograph, designed to fill the need for an extremely small flight-test instrument when automatic features are needed. Dimensions have been held to a minimum without affecting its ability to obtain highly accurate recordings. It measures stresses, strains, vibrations and other physical phenomena under extreme acceleration, shock and temperature conditions. Components will withstand severe conditions of both laboratory and field usage. A few features are: *Automatic record-numbering* • *Automatic length control (resettable by remote control)* • *No-record warning* • *Lamp burn-out indicators* • *Full width timing lines at 0.01 and 0.1 seconds* • *Trace identification* • *Footage indicator* • *Wide selection of paper speeds*

WRITE FOR COMPLETE DETAILS

products

- OSCILLOGRAPHS (LABORATORY AND FLIGHT TEST)
- MAGNETIC STRUCTURES
- GALVANOMETERS
- AMPLIFIERS
- HYDRAULIC SERVOVALVES
- TORQUE MOTORS
- SERVOAMPLIFIERS
- DATA REPEATERS
- WATERPROOF CONNECTORS
- GEOPHYSICAL EQUIPMENT

MIDWESTERN MI INSTRUMENTS

MIDWESTERN INSTRUMENTS

41st and Sheridan Road — Tulsa, Oklahoma

For more information circle 11 on inquiry card.

erator of electromagnetic waves with wavelength less than 1 mm. (frequency above 300,000 Mc.), thus closing an important gap in the spectrum. The Motz Millimeter Wave Generator uses a linear accelerator to produce a beam of electrons. This beam is made to oscillate in an "undulator," and the desired frequency is chosen by an echelette spectrometer (grooved aluminum plate) facing a parabolic mirror. The mirror reflects a pure wave of useful amplitude.

Exhibit of Novel Devices

PITTSBURGH, PA.—Many novel instruments of various types lie dormant in the minds and hands of their inventors because of lack of publicity. To remedy this situation, the management of the Second International Automation Exposition, to be held at Chicago Navy Pier, Nov. 14-17, 1955, is making free space available to inventors and others who wish to offer their brainchildren to industry. Inventors may show pilot models, mockups, drawings, etc. The only requirement is that the instrument must not be available commercially at the time of showing.

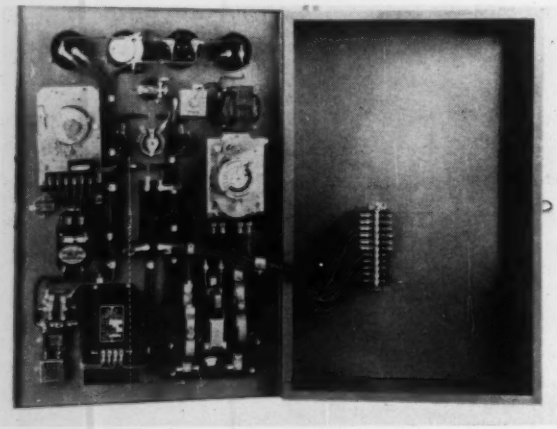
A separate area will be set aside at the Exposition for this display. The following requirements must be met:

1. The area devoted to a single instrument will be 4 sq. ft. of table space.
2. The appearance of each exhibit must not detract from the other exhibits.
3. The inventor must man the exhibit at all times.
4. A written application to exhibit should describe the display to be installed. If found acceptable an agreement form will be sent.

Write to: Second Automation Exposition, 845 Ridge Ave., Pittsburgh 12, Pa.

Power Line Control

CHICAGO, ILL.—A new automatic stop-start control panel has been installed by Illinois Bell Telephone Com-



pany to cut in an engine alternator during power failures or other emergencies. The panel designer, Industrial Control Panel Co., 247 E. Illinois St., Chicago, states that this new circuit is readily adapted to sequence operations, load transfer, machine tools, fuel flame control, etc.

Aluminum Resistivity

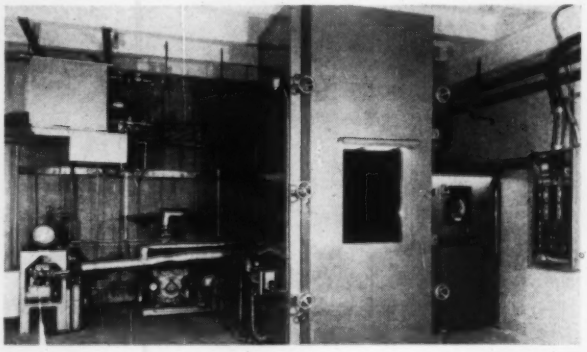
PHILADELPHIA, PA.—Delegates from Canada, France, Germany, India, Sweden, United Kingdom, and USA agreed on a basic international standard of resistance for aluminum, corresponding to the resistivity of very-high-purity aluminum. The meeting was held during the Fiftieth Anniversary of the International Electrotechnical Commission, Sept. 1-16. The basic value of resistance agreed upon is 1/37 (equals 0.027027) ohm mm. sq. per meter.

A value for resistivity of hard-drawn aluminum wire was tentatively approved. This is to be 0.028264 ohm mm. sq. per meter as the maximum resistivity.

Maximum resistivity for aluminum bus conductors was set at 0.0290 ohm mm. sq. per meter.

Environmental Testing

SILVER SPRING, MD.—Environmental test chamber at National Electrical Machine Shops, Inc., Silver Spring, Maryland, was especially designed by Bowser Technical



Refrigeration, Terryville, Conn. to accommodate communications and electronic instruments of unusual shape. Unit combines temperature range of –100 to +200 F., humidity from 20 to 95 percent, and altitude from atmospheric to 80,000 feet.

Vapor Transmission Apparatus

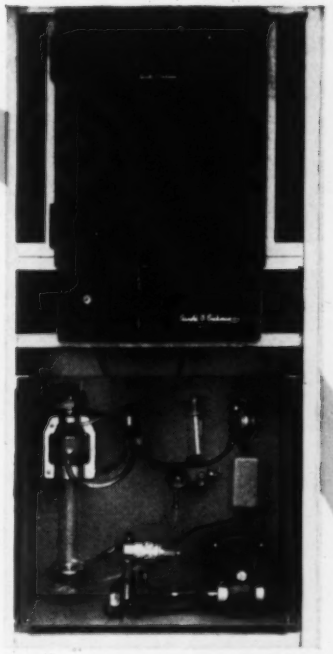
WASHINGTON, D.C.—An apparatus designed for measuring heat and water-vapor permeances of insulated panels has recently been developed by H. E. Robinson, F. J. Powlitch, M. A. Barron, and P. R. Achenbach of the National Bureau of Standards.

The apparatus consists of two parts coupled together to form a large, well-insulated enclosure. The test panel, 4 x 8

ft, is installed in one section against a gasketed stop in such a way that, when the apparatus is closed, it divides the enclosure into a warm side and a cold side.

Determination of heat flow through the panel is made by measurement of the average electrical energy input into the warm-side and of heat losses from the same side through all paths except that through the test panel. The difference is that going through the panel. Electrical energy input is measured by an integrating watt-hour meter. The heat

NEW
Arnold O. Beckman
DISSOLVED OXYGEN ANALYZER
for continuous measurement!



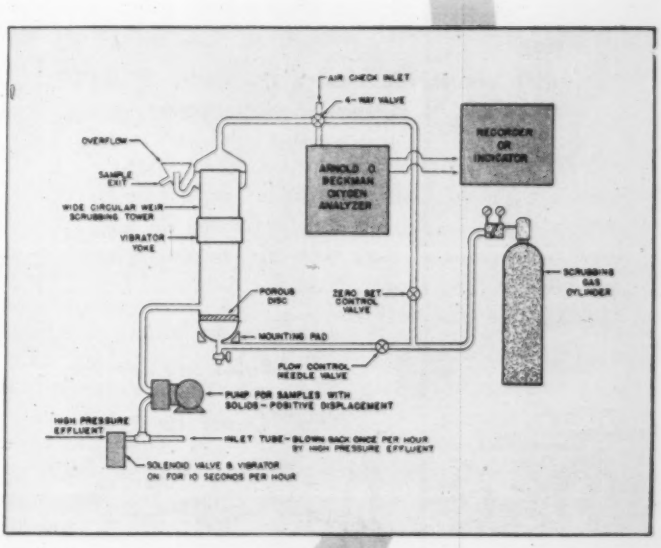
- Continuous record
- Handles fluids, slurries, sludges, etc.
- Simple operation
- Highly accurate

The accurate measurement of dissolved oxygen in fluid process streams is widely recognized as an important control factor in such municipal and industrial operations as sewage and water treatment . . . waste disposal . . . petro-chemical and chemical processes . . . food processes . . . and many others.

Now, you can make such measurements—continuously, simply and accurately—with the newly-developed Arnold O. Beckman Model 1A3B Dissolved Oxygen Analyzer!

The Model 1A3B is a complete, compact unit—with the Analyzer in top compartment and the scrubbing unit below.

- **The new Model 1A3B combines the field-proven Arnold O. Beckman paramagnetic principle of oxygen measurement with an improved method of stripping to provide a measurement specific for oxygen.**
- **The Model 1A3B is factory-calibrated to read in percent saturation so that efficiency of aeration or deaeration is shown directly. Or if preferred, the instrument can also be supplied to provide readings directly in parts-per-million.**
- **The Model 1A3B can be directly connected to any standard potentiometer-type recorder or indicator. No special accessory equipment is needed.**
- **Using the Model 1A3B is far superior—in speed, accuracy and convenience—to conventional chemical methods—and provides—immediately and continuously—the necessary control information for maintaining optimum processing uniformity.**


AIR CHECK INLET
4-WAY VALVE
OVERFLOW
SAMPLE EXIT
WIDE CIRCULAR WEIR SCRUBBING TOWER
VIBRATOR YOKE
ARNOLD O. BECKMAN OXYGEN ANALYZER
RECORDER OR INDICATOR
SCRUBBING GAS CYLINDER
POROUS DISC
ZERO SET CONTROL VALVE
MOUNTING PAD
FLOW CONTROL NEEDLE VALVE
PUMP FOR SAMPLES WITH SOLIDS - POSITIVE DISPLACEMENT
HIGH PRESSURE EFFLUENT
INLET TUBE - BLOWN BACK ONCE PER HOUR BY HIGH PRESSURE EFFLUENT
SOLENOID VALVE & VIBRATOR ON FOR 10 SECONDS PER HOUR

With a few variations the Model 1A3B can be adapted to a wide range of application requirements . . . to handling sludges and other liquids having high concentration of solids . . . to handling samples under abnormal pressures or temperatures . . . and to other difficult sampling conditions.

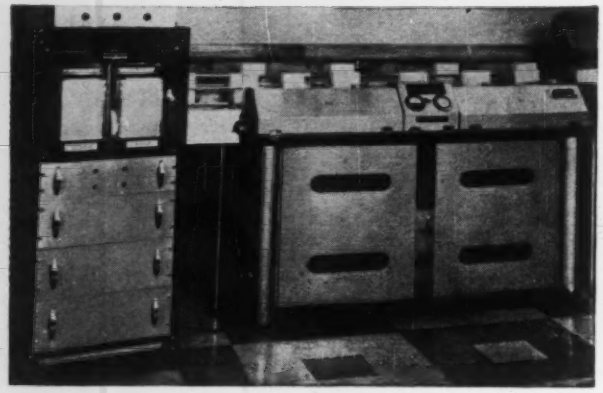
The Principle is simple and positive. The constantly-fresh test sample in scrubbing tower is stripped of dissolved oxygen by inert scrubbing gas—and result measured by Analyzer. Measurement is continuous and accurate!

RANGES—from a maximum of 0-100% O_2 saturation to a minimum of 0-5 ppm, full scale. Intermediate ranges are also available.

Arnold O. Beckman INC.
1020 MISSION STREET, SOUTH PASADENA, CALIFORNIA

Get the full story *on this new Arnold O. Beckman development by writing directly for information on the Model 1A3B Dissolved Oxygen Analyzer. Ask for Data File # 13G-25.*

For more information circle **12** on inquiry card.



SELECTROL

gives you automatic weight control . . . at HIGH SPEED!

- **. . . checks every package, eliminates "sampling"**
- **. . . rejects over-weights and under-weights into separate groups**
- **. . . charts average and range of weights for statistical control of filling operation**
- **. . . with electronic controls, adjusts filling machines in closed-loop operation**

SELECTROL is a time-proven production machine backed by more than 40 years of experience in industrial weighing, and is in use today on hundreds of production lines both for checkweighing and inspection by weight. Write for details on how SELECTROL can work for you.

Sales and Service from Coast to Coast

Exact Weight Scales

Better quality control
Better cost control

THE EXACT WEIGHT SCALE COMPANY

951 W. Fifth Avenue, Columbus 8, Ohio
In Canada: P. O. Box 179, Station S, Toronto 18, Ont.

For more information circle **13** on inquiry card.

losses are determined by measuring certain temperature differences and using appropriate calibration procedures.

The rates of flow of water vapor into the warm face of the panel, and out of its cold face, are based on the average rates at which it is necessary to evaporate water on the warm side, and to absorb vapor on the cold side, so that their humidities are kept at the desired constant levels. Illustration shows instrument console (left), panel test apparatus (in vertical position), desiccant box, and oven for regenerating desiccant.

Tourist Aid

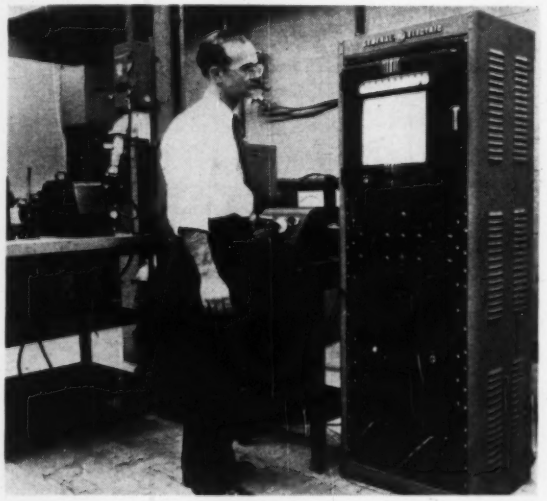
VIENNA.—An Austrian inventor has built an electronic "travelers' friend" to solve lodging problems for weary tourists arriving at terminals.

A luminous wall panel lists all hotels, their outstanding features and their prices, while electrically lighted figures give an up-to-the-minute report on how many rooms are available at each. Other lighted symbols tell how to reach the hotels by bus or on foot.

One of the gadgets already is in operation at the railway station in the city of Linz; others are to go up soon in Vienna and other Austrian travel centers.

Hysteresigraph

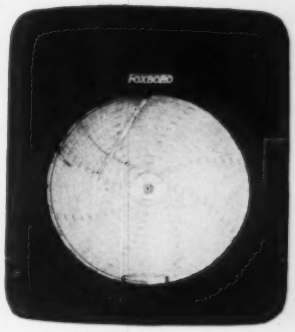
DETROIT, MICH.—This recording hysteresigraph in Carboloy Department's new magnet laboratory, makes a complete and accurate record of a magnet's entire hysteresis loop automatically. Any or all parts of the major or minor loops can be explored at will by the operator and recorded for future use in the design work done by application engineers. Sample being tested is located between the poles of the isthmus electro-magnet on the table at the left. The knob being turned by the operator controls the amplidyne generator used to supply the magnetizing current.



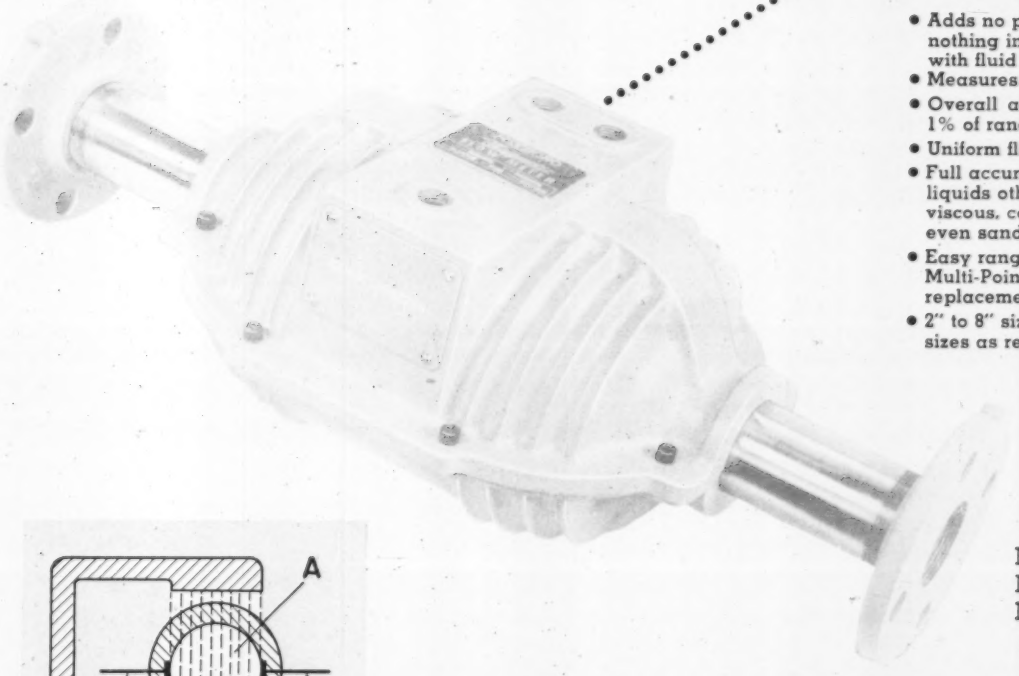
Germanium Diodes

WOBURN, MASS.—Sylvania Electric Products Inc. announces it has developed a manufacturing process that will increase the stability and life of germanium diodes. The process produces germanium with a molecularly stable surface. The rectifying action of a germanium diode is accomplished by a barrier which is formed at the time the diode is made and gives it the desired characteristics. Diodes made in the past have occasionally developed a second barrier on the surface of the germanium. This unwanted barrier is

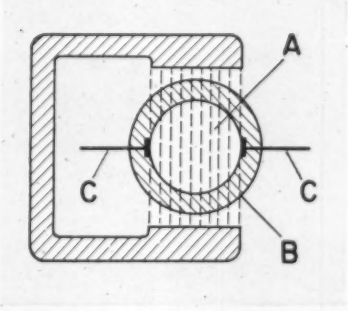
NEW! a flow meter with no flow restrictions!



- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Full accuracy sustained even on liquids other meters can't handle: viscous, corrosive, or pulpy — even sand-water slurries.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 2" to 8" sizes standard — larger sizes as required.



FOXBORO MAGNETIC FLOW METER



SIMPLE, TROUBLEFREE, OPERATION

The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

This premium-performance meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by 2-conductor cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul.

Foxboro Magnetic Flow Meters are already in use on such widely different liquids as beer, sand-and-water, rosin size, rock-and-acid slurry, viscose, and highly corrosive liquid detergent. Find out how this precise, troublefree flow meter can help *your* processing. Write for complete details.

THE FOXBORO COMPANY, 463 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

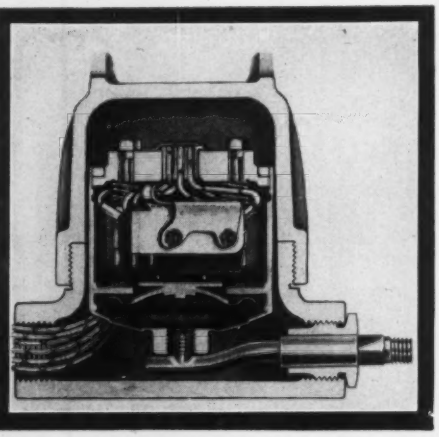
FOXBORO
REG U. S. PAT. OFF.

Foremost in FLOW METERING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

For more information circle **14** on inquiry card.

New Improved

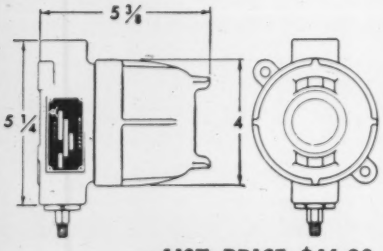


MELETRON PRESSURE SWITCH

for Explosive Atmospheres

- **LOW COST** *because of design simplicity*
- **SMALL and COMPACT** *for easy installation*
- **EXTREME ACCURACY** *moving and wearing parts are eliminated*
- **NOT AFFECTED BY VIBRATION** *no liquid switching elements are used*
- **RUGGED and WEATHER RESISTANT** *enclosed in a crouse-hinds case*
- **EASILY ADJUSTABLE** *by convenient adjusting nut*
- **OPERATES IN ANY POSITION** *saves installation time*

ACTUAL SIZE



LIST PRICE $46.20

BARKSDALE VALVES

PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

send FREE operating and engineering data sheets 920-25

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

For more information circle **15** on inquiry card.

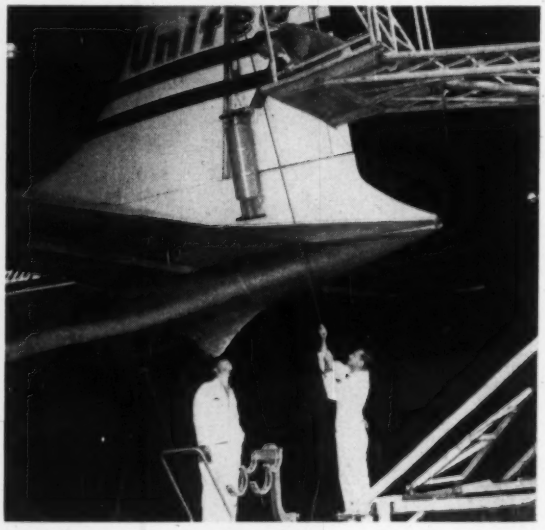
electrically opposed to the original one, which results in unstable operation. The new process is said to lock in permanently the characteristics that initially are built into diodes.

Magnetic Memory

NEW YORK, N. Y.—A new high-speed magnetic memory for Burroughs ENIAC (Electronic Numerical Integrator and Computer) increases ENIAC's memory capacity from 20 to 120 words. The static magnetic memory stores 120 ten-decimal digit words in 4100 rectangular-hysteresis-loop ferromagnetic cores. ENIAC is one of the first and best-known digital-type computers.

Aircraft Inspection

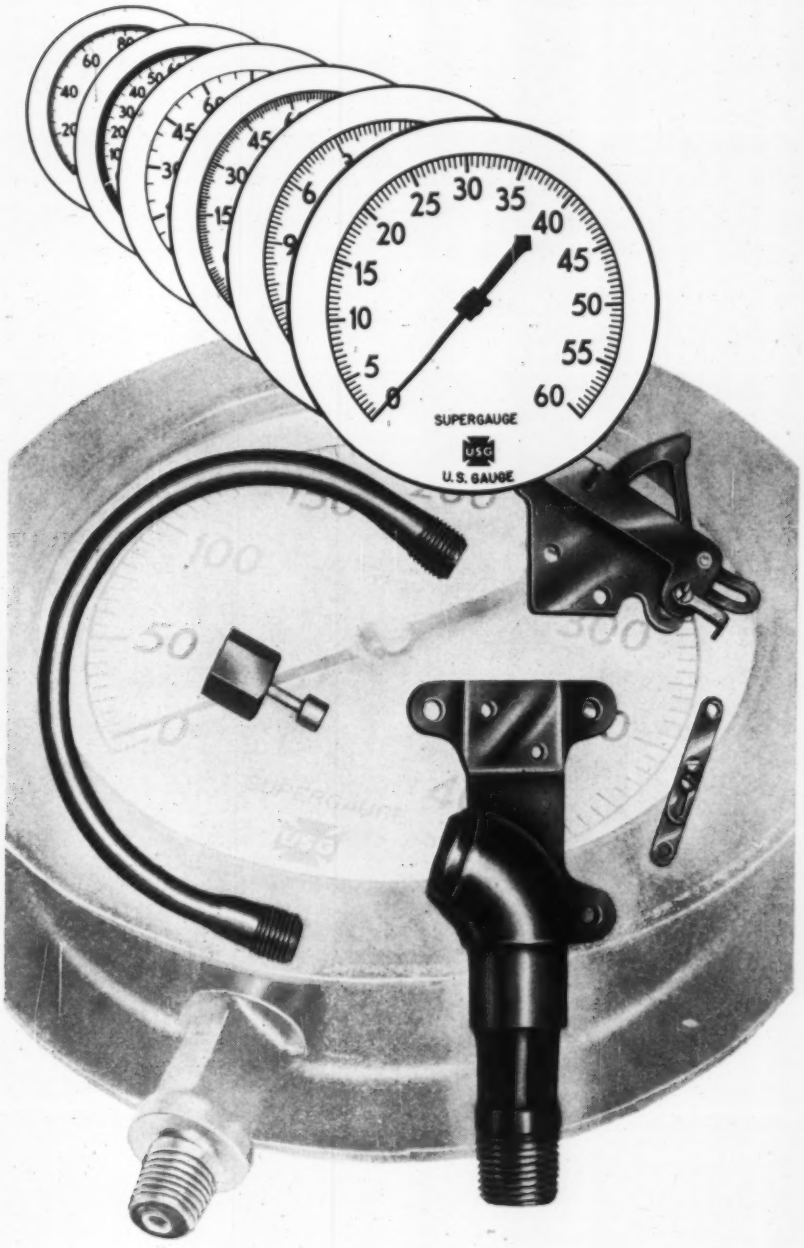
SAN FRANCISCO, CALIF.—Portable X-ray unit, employed for aircraft inspection at the San Francisco "push-button" maintenance base of United Air Lines, is here



hoisted into position on DC-6 Mainliner. The portable X-ray unit is manufactured by the C. H. F. Muller Company of Hamburg, Germany, and distributed in this country by the North American Philips Company, Inc., under the trade name "Norelco."

Ceramic Thickness Gage

SAN DIEGO, CALIF.—Thickness of Ryan ceramic coatings can now be measured within 0.0005 inch by a new instrument which has been built by the Ryan Development Laboratory. Designed by the National Bureau of Standards, the new device provides a nondestructive method for deter-



MANY USG STOCK GAUGES ARE "SPECIALS" WITH OTHER MAKERS

For over 50 years USG has been designing and producing gauges for more original equipment manufacturers than any other instrument company in the world.

Many of USG's "special" designs have become standard stock items in the industry. Many others that are "standard stock" at USG require expensive special production with other instrument manufacturers.

To meet special gauge requirements economically, USG maintains the world's largest stock of gauge components to meet any pressure sensing and actuating need.

In addition to these huge stocks for special designs, USG inventories over 200,000 standard gauges in a variety of types, sizes and ranges for practically every industry application.

To assure higher quality gauges with enduring accuracy, USG maintains the most rigid quality control system in the instrument industry. This rigid inspection system is supported by a Standards Laboratory with masters measuring from low vacuums to super pressures.

USG's facilities are economically integrated for large volume, quality controlled production, assuring better gauges—with enduring accuracy—*in every competitive price class.*

A "*special*" that's standard

Special production of a gauge is expensive. Production of a special design is even more expensive.

USG helps you lower your gauge costs by stocking the world's most complete line of gauge components to meet almost every requirement of size, pressure, mounting, case and internals for all operating conditions.

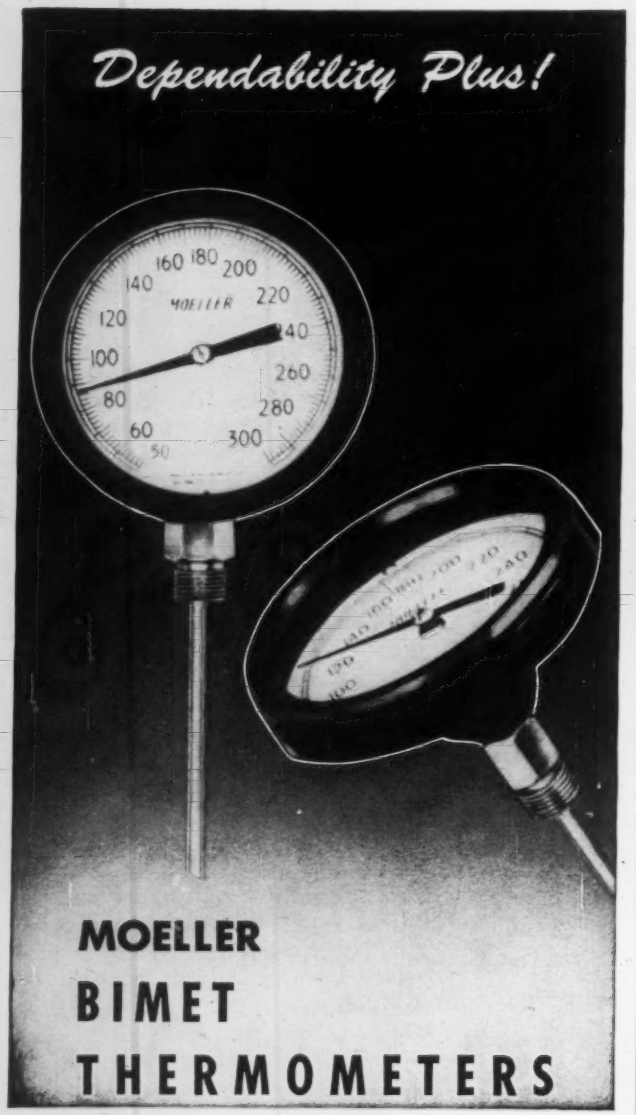
For help with all your gauge and other pressure sensing and actuating devices, call your nearest USG District Office or write to us at Sellersville.

Above, a portion of USG's Research Laboratory. Here constant testing of materials under customer operating conditions assures optimum efficiency and long gauge life.

UNITED STATES GAUGE *Gauge Headquarters* FOR OVER 50 YEARS

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

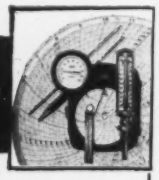
For more information circle **16** on inquiry card.



No doubts, no indecisions . . . When you need accuracy most and want to know that you can absolutely rely on correct, accurate readings, Moeller Bimet Thermometers live up to their reputation for dependability.

Sturdy mechanisms enclosed in durable cases guarantee continued top performance.

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities



Gentlemen: Without obligation, please send me Moeller Bimet Thermometer Bulletin No. 225 B.

NAME .....

FIRM .....

ADDRESS .....

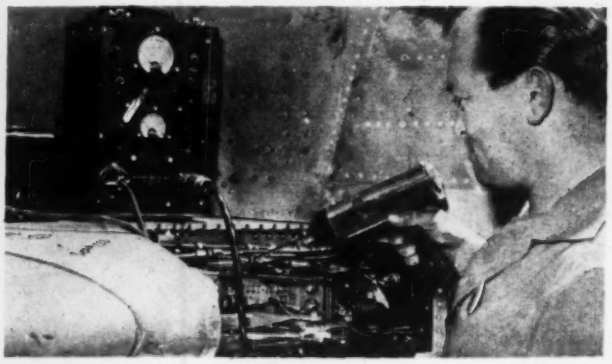
CITY ..... ZONE ..... STATE .....

For more information circle **17** on inquiry card.

mining the gage of protective coatings applied to nonmagnetic materials. The instrument consists of a plastic test head in which an electromagnetic probe coil is embedded, and an inductance balance indicator which utilizes a galvanometer. Principle involved is the well-known change in inductance of a coil when it is brought in proximity to a metal surface.

Leak Detector

LOS ANGELES, CALIF.—Leaks in fuel cells of aircraft being manufactured at the Los Angeles plant of North American Aviation, Inc., are quickly checked by use of a



portable leak detector. The equipment, developed by General Electric, can discover openings so small that only 1/100 of an ounce of air would escape in a year. A small amount of halogen is injected into the empty fuel system prior to its installation in the airplane, and is maintained under a specific pressure. The G-E detector is then run over the system.

New Odor Theory

CAMBRIDGE, MASS.—An information theory of olfaction has been prepared by physicists at Arthur D. Little, Inc., Cambridge, Mass. The theory is based on a nerve network that uses odor information in much the same way as a computer handles its instructions.

People can recognize 10,000 distinct odors, and can detect fantastically tenuous odors, but are poor in distinguishing a strong odor from a slightly weaker one of the same kind. Each nostril has a lobe about as big as the end of the thumb. The lobe is made up of some 1900 "telephone exchanges" called glomeruli; each of these sends 24 nerve fibers, or neurons, to the brain.

The physicists compare these bundles of 24 neurons to a board with 24 lights. By turning on some of the lights, a recognizable picture can be formed. Similarly, when a man smells chloroform, the theory suggests that particular ones of these 24 neurons "light up" to form a code for chloroform and for nothing else. With only 24 neurons, it is possible to get 16,000,000 different patterns, corresponding to 16,000,000 different odors! The kind of odor depends on the pattern, but the strength of the odor depends on how many of the 1900 bundles of 24 neurons react to the chloroform, which in turn depends on how much chloroform there is in the air. Here the physicists show by some complicated arithmetic that this arrangement permits the smeller to discriminate only about 30 levels of intensity, and they find by talking to expert smellers that, as a matter of fact, a group of well-trained people can distinguish at best some 25 to 30 degrees of strength and no more.

The bundles of 24 neurons differ from the board of 24 electric lights in that they are not continuously lit or unlit; instead, the neurons send electrical pulses to the brain 10 times a second.

No maintenance problems with this instrument!

In spite of all of the development work being done on automatic control instruments, the Bristol Series 500 Air-Operated Controller is still the most dependable and trouble-free — as proved by thousands of installations. And here's why:

It's the simplest to service. Only one adjustment with a ¼ in. wrench calibrates the control system. No other adjustment is needed. Control system can be completely disassembled and, after reassembly (even with replacement parts), can be *exactly calibrated by this one simple adjustment.*

It's completely reliable. One user states, "I'm amazed at the way this instrument performs day-in and day-out with little or no attention. We call it the workhorse controller in our plant. And our plant men like to use it, because it gives them the precision results they need without having to fuss with it".

Its settings are exactly reproducible. Reset rate, derivative time, and proportional band adjustments are accurately calibrated and exactly reproducible. You can instantly reproduce established settings without cut and try.

It uses the world-famous Bristol measuring elements. The measuring systems used in Bristol Series 500 Air-Operated Controllers for TEMPERATURE, PRESSURE, FLOW, VACUUM, DRAFT, ABSOLUTE PRESSURE, LIQUID LEVEL, pH, AND HUMIDITY are the result of 65 years of experience in instrument making and application in practically every industry. Bristol measuring elements are recognized the world over for their accuracy, simplicity, and reliability. There just aren't any better measuring elements made than Bristol's.

For more facts and figures about the Series 500 Air-Operated Controllers, write for free 32-page bulletin A120. The Bristol Company, 113 Bristol Road, Waterbury, Connecticut.

4.27

TRADE MARK
BRISTOL'S
REG. U.S. PAT. OFFICE

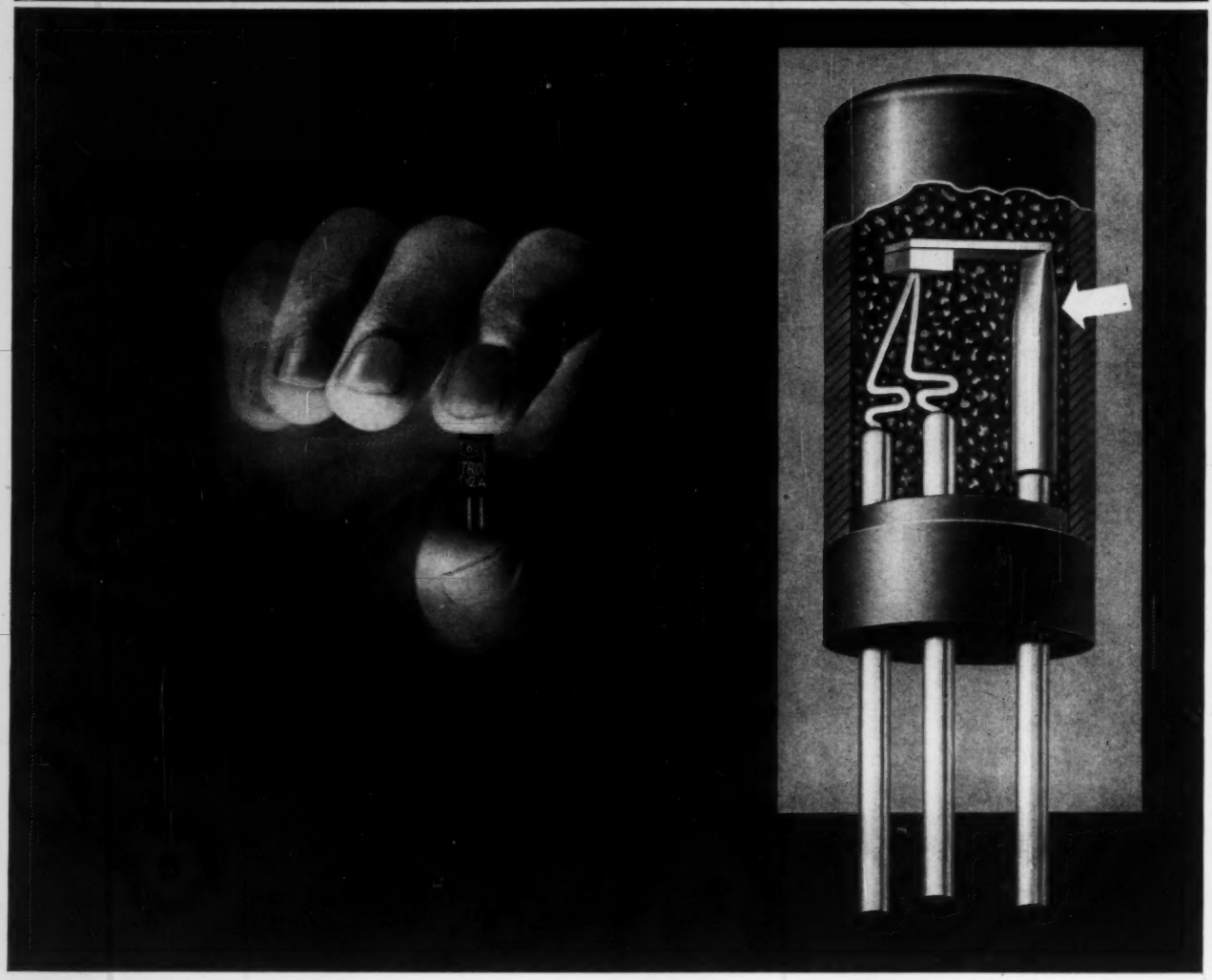
BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **18** on inquiry card.

Look what's happened to the "cat's whiskers"



A miracle that can hide behind your thumb-nail is the hottest electronics news in years. Modernized descendant of the Twenties' crystal diode with its cat's whisker, the transistor threatens to send many vacuum tubes the way of old head sets.

No matter which ultimately gets the nod—tube or transistor—Superior will be in there pitching. Superior seamless and Lockseam* nickel cathodes, anodes and grid cups are familiar to you in vacuum tubes. Now Superior tubing is going into transistors.

CBS-Hytron, a division of Columbia Broadcasting System, Inc., uses Superior tubing for the L-shaped bracket that holds the germanium crystal in their PT-2A point-contact transistor. For this purpose they purchase tiny tubes—.032" I.D. x .003" wall, .193" long, drawn from seamless nickel. Added to the good welding, soldering and formability characteristics of the metal, Superior manufactures the brackets to the close tolerances CBS-Hytron must have.

Whether you are for the old or new order in electronics, if you need an idea or an analysis in small tubing, Superior is the first place to look. Superior Tube Company, Electronics Division, 1968 Germantown Ave., Norristown, Pa.

All analyses .010" to ⅜" O.D.

Certain analyses in Light Walls up to 2½" O.D.

Seamless Nickel Anode. Flattened one end. .500" O.D. x .025" Wall x 1.625" long.

Seamless Nickel Cathode. Round, flanged oneend, .070"/.072" I.D. x .0025" Wall. .295" long.

Lockseam* Nickel Cathode. Round, tabbed, single bead, .045" O.D. x .0021" Wall. 27 mm long.

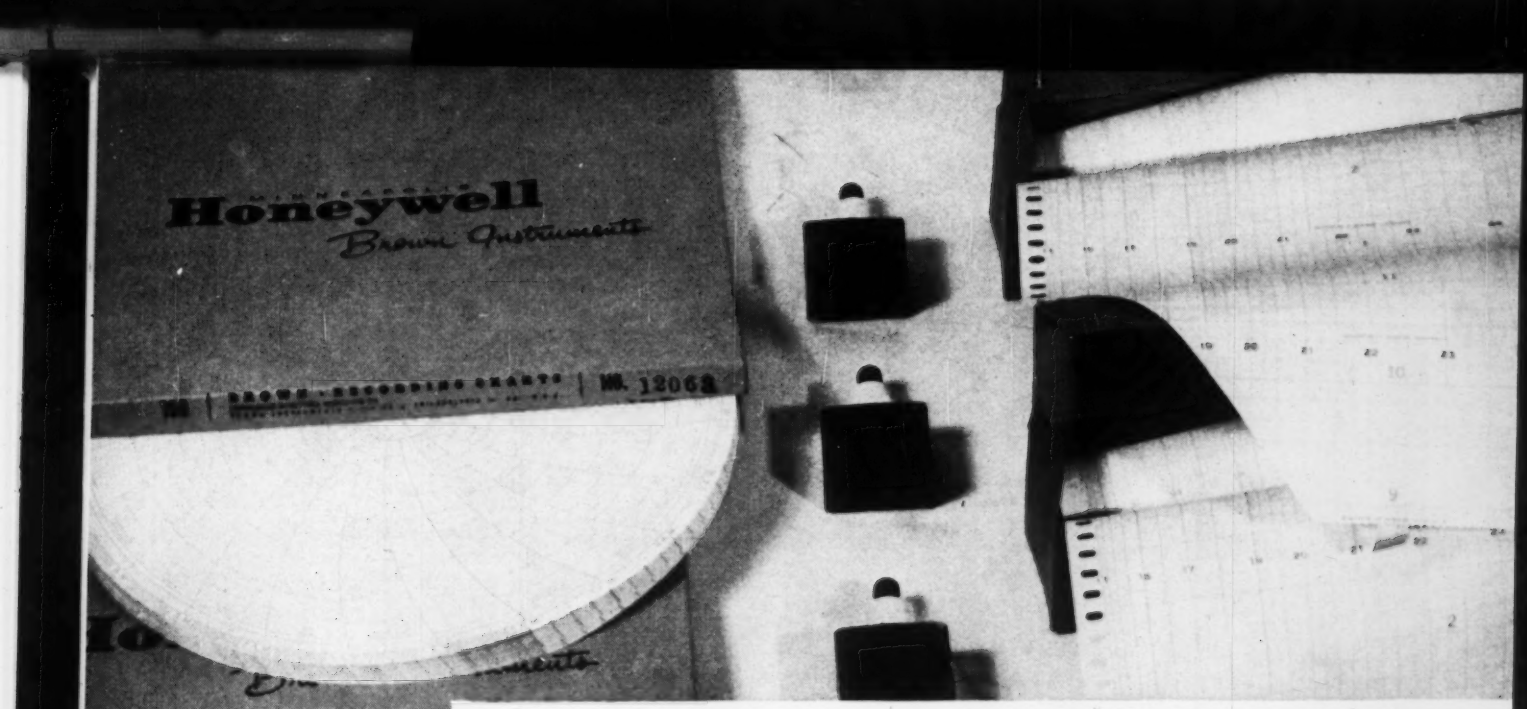
Disc Cathode .121" O.D. .312" long.

Many types of nickel cathodes—made in Seamless and Lockseam* from nickel strip, disc cathodes, and a wide variety of anodes, grid cups and other tubular fabricated parts are available from Superior. For information and Free Bulletin, address Superior Tube Company, Electronics Division, 2500 Germantown Avenue, Norristown, Pa.

*Manufactured under U.S. Patents.

For more information circle **19** on inquiry card.

For more information circle **20** on inquiry card. →



NEW recorder charts!

NEW inks!

available through your **HSM** HONEYWELL SUPPLIES MAN

Meet the brand new line of Brown recorder charts and inks . . . the finest "team" ever developed to give you the peak in recording performance on your Brown instruments.

The new strip and circular charts are made of the highest grade pulp, quality-controlled for perfect appearance and texture. They're given a special internal and external sizing to produce a superior writing surface that won't feather or strike through. Stretching and shrinking due to changes in humidity are practically eliminated.

The new inks are custom-made to write sharp, clear records on the new papers. They dry quickly . . . yet give minimum evaporation in the pen reservoir. A selection of brand new colors is available, including a deep black suitable for blueprint reproduction.

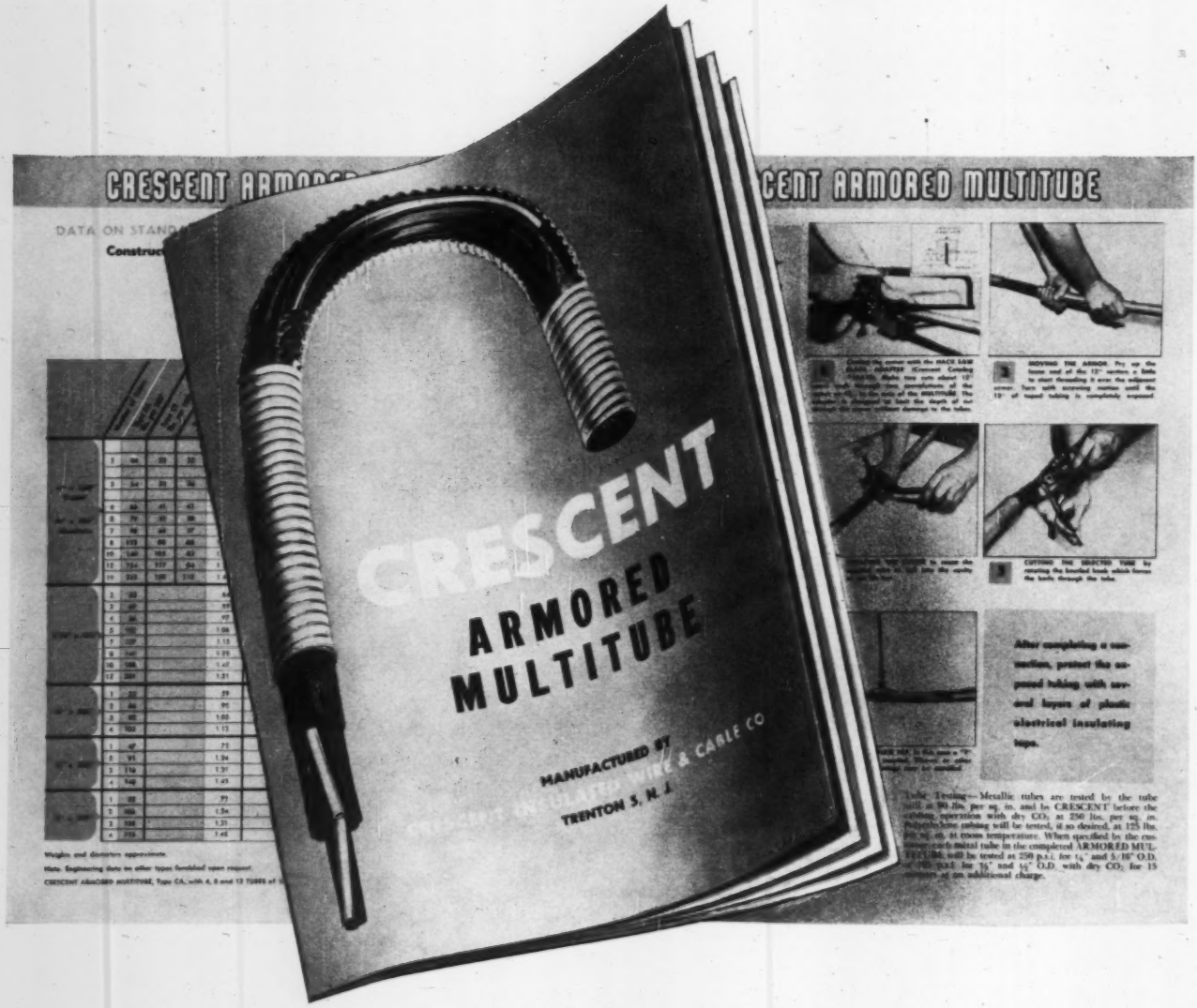
Ask your local Honeywell Supplies Man about these new papers and inks . . . and about the economical, convenient HSM Plan for purchasing pyrometer supplies. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for new Booklet, "The HSM Plan for Purchasing Pyrometer Supplies."**

MINNEAPOLIS **Honeywell**
BROWN INSTRUMENTS
First in Controls

Fast Service on your orders for charts, and other pyrometer supplies, is expedited by this teletype equipment at Honeywell stock headquarters.



This New Bulletin Gives You Latest Engineering Data on CRESCENT ARMORED MULTITUBE

Much information on this interesting new product is included in this 8-page, 2 color folder, including illustration and description of the regular copper and aluminum Multitube, the three corrosion resistant types, and the Polyethylene Multitube. Complete data on construction of all types is given, as well as a clear pictorial description of the method of tapping into any tube in the outer layer.

The trend toward automation in industry makes the control system in many factories of the greatest importance. For complete protection of your tubing at substantially lower installation cost, by all means investigate CRESCENT ARMORED MULTITUBE. A request on your letterhead for a folder will receive immediate attention.

Long length tubes twisted together permits bending without any distortion of the tubes.

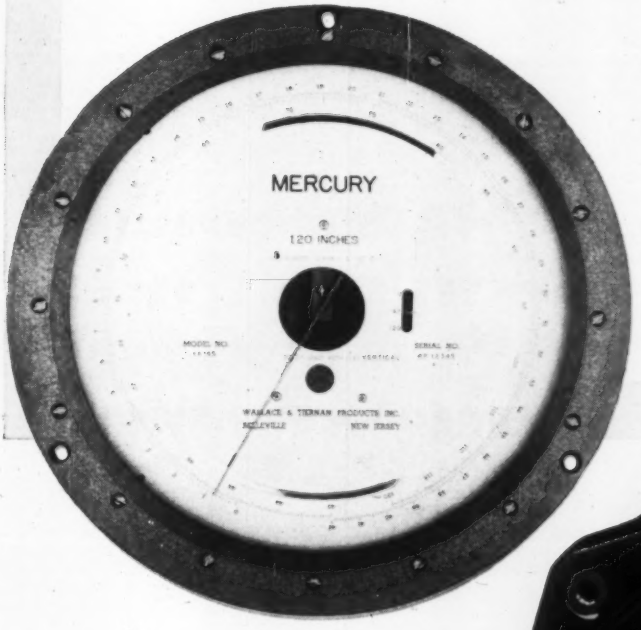
CRESCENT
INSULATED WIRE & CABLE CO.
OLDEN & TAYLOR STS., TRENTON, NEW JERSEY

For more information circle **21** on inquiry card.

PRECISION PRESSURE MEASUREMENT

of Gauge Pressure, Vacuum or Differential Pressure

Precision Dial Manometer Type FA-145



Accuracy:
1 part in 1000 over full scale.
Sensitivity:
1 part in 10,000 in *all* ranges.
Ranges:
0 to 120 inches of water (min.)
0 to 250 inches of mercury (max.)
Other intermediate ranges available.
Scale Length:
45 inches.
Dial Diameter:
8½ inches.

Precision Low Pressure Gauge Type FA-141

Accuracy:
1 part in 300 over full scale.
Sensitivity:
1 part in 500 in *all* ranges.
Ranges:
0 to 10 inches of water (min.)
0 to 400 inches of water (max.)
Other intermediate ranges available.
Scale Length:
7 or 16 inches.
Dial Diameter:
2¾ or 6 inches.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST., BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

For additional data, write for Publication TP-30-A and TP-27-A

A-101

For more information circle **22** on inquiry card.

NEW! ASHCROFT 2½" GAUGE

HAS TYPE 316 STAINLESS STEEL SYSTEM TO WITHSTAND CORROSIVE CONDITIONS

High resistance to corrosion and sustained high accuracy are combined in this new heavy-duty Ashcroft Gauge. The 2½" dial size makes this compact instrument ideal for small tanks and processing equipment where large pressure gauges would be impractical. Bourdon tube (welded at socket and tip) . . . square shank and ¼" male N.P.T. bottom connection . . . geared movement—the entire gauge system is Type 316 stainless steel.

Made in standard graduations from 30 psi through 1,000 psi, this new Ashcroft Pressure Gauge has a black dial with easy-to-read white figures. The drawn steel case and threaded ring are finished in black. Pointer is precision needle type. Every part is designed, tested and manufactured to meet rigid service conditions.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR now has this new Ashcroft Gauge in stock. Let him know your requirements. You can depend on him for experienced counsel and prompt delivery.

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

1850 ASHCROFT U.S.A.

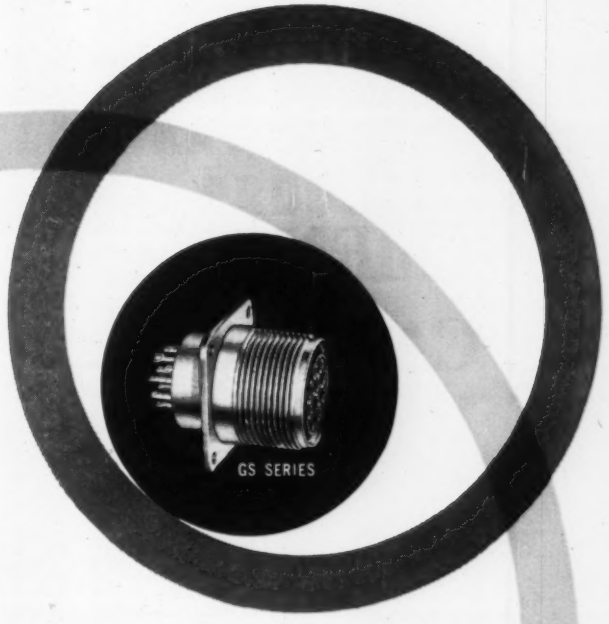
ASHCROFT GAUGES

MAXWELL MANNING M&M MOORE INC. TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

For more information circle **23** on inquiry card.



for **TRUE**

HERMETIC

SEALING

connect with cannon!

Hermetically-sealed multi-contact connectors made by Cannon are really rugged! And . . . they are the only connectors that give you **true hermetic sealing under such adverse pressure and atmospheric changes.** Here's why . . .

Cannon pioneered the first successful hermetically-sealed connector more than six years ago . . . since then has continuously refined and increased the line. All have special steel contacts. Vitreous insulation . . . **fused to both contacts and shell for a perfect permanent seal** . . . is stronger than steel, withstands temperatures to 600° F, and permits the use of the **highest conductive steel** contacts compatible with any vitreous fusing operation.

Available in a wide variety of insert layouts for control, relay, power, and instrument applications in Series GS, (AN type), KH, RKH, U, DAH, BFPH, TBFH, DBH, DCH, KOH, standard, miniature and sub-miniature sizes. Also, special mounting flanges and brazing service to help you obtain a strong and leakproof overall assembly.

CANNON PLUGS

first in connectors

DH SERIES

U SERIES

KH SERIES

Please refer to Dept. 180

CANNON ELECTRIC COMPANY, 3209 Humboldt Street, Los Angeles 31, California

Factories in Los Angeles; East Haven; Toronto, Canada; London, England.
Representatives and distributors in all principal cities are at your service.

For more information circle **24** on inquiry card.

Initial Announcement

THE 1956 INSTRUMENTS and AUTOMATION CATALOG and INDEX

Publication date, July 1955

CIRCULATION: The *Index* will be sent to 20,000 users of instruments and devices for measurement, inspection, testing and control. These are the 20,000 most important men who buy, install and maintain instrument and control devices.

COMPLETE HORIZONTAL COVERAGE of the men who buy and specify instruments and controls in every major instrument-using company. The *Index* reaches the largest number of potential instrument buyers at lowest cost.

PRODUCTS ADVERTISED are scientific and industrial instruments; automatic electrical, mechanical, hydraulic, electronic and pneumatic controls; electric and electronic instruments; testing machines and devices; inspection devices and gages; control valves; relays; timers; laboratory and glass apparatus; etc.

CLOSING DATES: Copy to prepare, all details must be in our Pittsburgh Office not later than April 1st. Layout and copy will be sent to the advertiser for his OK and also final proofs.

Copy to set	May 20th
If no proof required	May 25th
Complete plates	June 1st
Inserts	June 15th

Advertisers' Names **Boldface** in Descriptive Directory: Advertisers in the *Index* will have their names in boldface type in the Descriptive Directory Section and reference will also be made to the page number (s) on which their advertisement (s) appear. This gives to the individual seeking information the two vitally important elements of the *Index*—1. Where he can buy it, and 2. Technical data, when he turns to the page to which he is referred.

To increase the inquiry-producing power of this buying directory, the *Index* will include, in the alphabetical list of manufacturers: (1) Names of cities where the company has branch offices; and (2) Names and cities of the company's Authorized Agents.

RATES and Mechanical Requirements: Advertisers will be entitled to the rate earned in the 12 regular issues of *Instruments* and *Automation* or to the rate they earn in the *Index*, whichever is most advantageous. Space used in the *Index* will not help earn a rate in the regular issues of *Instruments* and *Automation*. But the rate earned in the regular issues will determine the rate for the *Index*.

INDEX RATES ARE THE SAME AS REGULAR *INSTRUMENTS & AUTOMATION* PER PAGE RATES

1 Page	$360.00	6 Pages	$314.00
2 Pages	354.00	8 Pages	302.00
3 Pages	344.00	9 Pages	297.00
4 Pages	338.00	12 Pages	275.00

All AAAA Standard Colors: Red, blue, yellow, orange, green, $100.00 per page for any one color. Matched colors $120.00 per page for any one color. Rates for metallic inks quoted on request. Bleed Pages: per page, extra $75.00

Rates for Complete Inserts:

2 Pages (backed up)	$ 530.00
4 pages (backed up)	1150.00
8 Pages (backed up)	2050.00

Mechanical Requirements

	Width	Depth	Width	Depth
1 Page	7	10	———	———
⅔ Page	4½	10	———	———
½ Page	3⅓	10	7	4⅝
⅓ Page	2⅛	10	4½	4⅝
¼ Page	3⅓	4⅝	———	———
⅙ Page	2⅛	4⅝	———	———

Halftones should be 110 screen.
Page trim size—8¼" wide x 11¼" deep
Bleed size—8⅜" wide x 11½" deep
Actual type measurement inside border.

INSERTS (Letterpress): Rates for complete inserts apply on inserts which are ready for binding when received. Before making plates or ordering printing please check with the Pittsburgh Office as to number of pages, quantity required, trim size. Maximum acceptable weight 100 lb. coated, 25 by 38 inch basis, or equivalent.

REPRINTS: Regular run of book stock will be used unless special stock is supplied by the advertiser. For reprint costs write Pittsburgh Office.

INSTRUMENTS PUBLISHING COMPANY

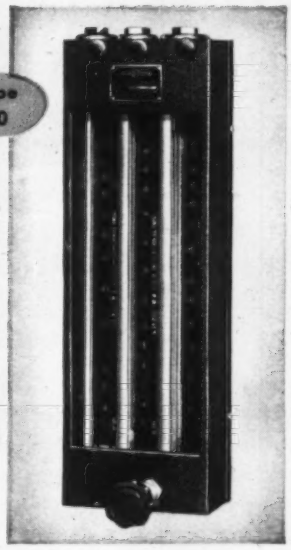
845 Ridge Ave., Pittsburgh 12, Pa. **Telephone: Fairfax 1-0161**

See Page 165 For District Offices and Managers

DO YOU USE FLOWMETERS FOR LABORATORY RESEARCH OR PRODUCTION?

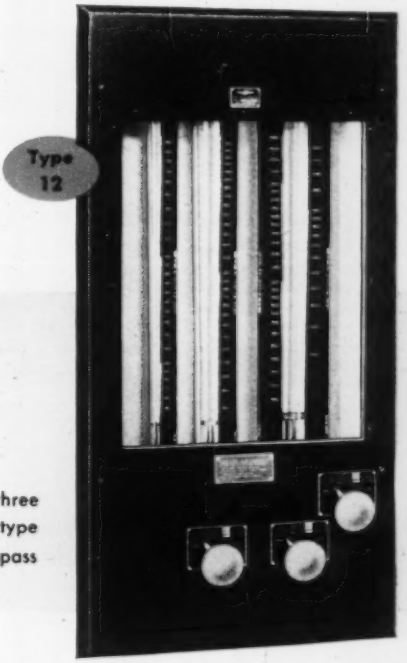
COX FLOWMETERS

are designed for flow rate measurement of fuels (such as gasoline, kerosene, diesel and jet fuel) and of many liquids and gases. They are built for use in the laboratory, in a wide range of production processes, or for a combination of the two.



For the Laboratory: *Type 10 Multiple Stage Flowmeters,* designed as a compact laboratory instrument for precise measurement of smaller fluid flow rates.

For Production: *Type 8 Single Stage Flowmeters,* engineered for a maximum flow capacity of 50,000 pounds per hour.



For Both: *Type 12 Multiple Stage Flowmeters,* available in three series — the 40, the 90, and the 100. Each has logarithmic type scales for excellent readability and can be equipped with a bypass orifice to greatly increase flow capacity.

Individually graduated scales; patented "Inner Wall" guides that insure perfect float centering within the metering tube; and extra-sensitive floats are a few of the major features of Cox Flowmeters. Scales are graduated for a specific fluid. Scales for metering other fluids can be easily interchanged. Multiple Stage Flowmeters are available for wide flow ranges, and bypass orifices can be built in which greatly increase the flow capacities without increasing panel space required.

The Type 12, 40 Series Flowmeter, available in single and multiple-stage units, is firmly established as the most accurate variable-area flowmeter now made. Each individually graduated logarithmic scale is accurate to within ±½ percent of the actual flow at any point on the scale. It is readable to within ±¼ percent of indicated flow at any point.

Look for Other CRL Products

AIR FLOWMETERS
CARBURETOR FLOW STANDS
ENGINE INDICATORS
FLOWMETER CALIBRATING STANDS
FUEL NOZZLE TEST STANDS
MAGNETIC THICKNESS GAGES
VIBRATION RECORDING EQUIPMENT
BALANCED ELECTRONIC EQUIPMENT FOR PRESSURE AND VIBRATIONS

Commercial Research Laboratories, Inc.

20 BARTLETT AVENUE • DETROIT 3, MICHIGAN

Makers of COX FLOWMETERS REG. U.S. PAT. OFF. TRADE MARK *Since 1912*

U. S. PATENTS 2,384,800
2,389,457
2,403,849
2,417,352

For more information circle **26** on inquiry card.

For Dependability in Critical Circuits...

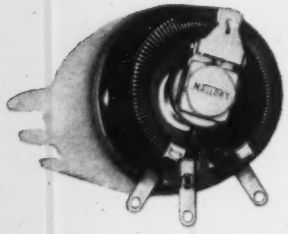
Specify MALLORY Resistors

Vitreous Enamel Resistors

For use as dropping resistors, voltage dividers, etc., Mallory vitreous enamel resistors are rated for continuous duty at ambient temperature of 65°C. Long service and excellent stability are the results of using highest quality ceramic core, wire and enamel coating. Fixed and adjustable in ratings from 5 to 200 watts.

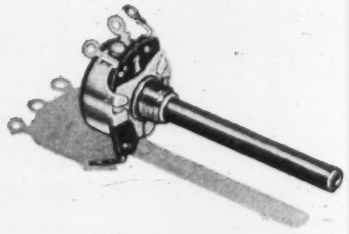
TO meet the increasingly stringent demands of modern instrument circuits, Mallory offers an extensive line of top-quality fixed and variable resistors. Used for years by leading manufacturers of electronic equipment, these components can be relied upon for stability, precision and long service life to meet your most exacting specifications . . . at economical cost.

In addition to the standard lines of resistors shown here, Mallory supplies a number of types of adjustable wire-wound resistors, and high power rheostats. For technical information on any of these, and for engineering assistance in their use in your own circuits, write or call Mallory today.



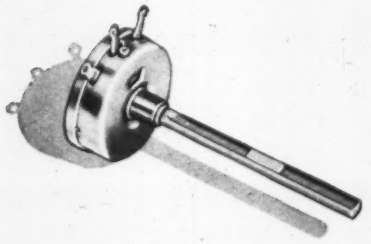
Power Rheostats

Especially useful in instrument circuits is the Mallory 25-watt rheostat. Exclusive hinged contact arm permits inspection or cleaning of brushes without changing contact pressure. Tapered windings are produced by a special variable pitch winding method that eliminates welded joints and hot spots. Other ratings up to 500 watts are available.



Variable Carbon Controls

Only $1\frac{5}{16}$" in diameter, these carbon controls fit readily into crowded chassis layouts. A special Mallory process produces resistance elements with high stability and minimum drift under adverse climatic conditions. Electrical noise is exceptionally low. Available in a complete range of tapers and resistance values, in both single and dual types.



Wire-Wound Controls

Famous for long service and superior performance, Mallory wire-wound controls cover the range from 2 to 7 watts, in resistances from $\frac{1}{2}$ to 150,000 ohms. Single, dual and triple sections and "T", "H" and "L" pad attenuators are available, with linear or special tapers.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
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New M-R-C SUPER-PRECISION *Instrument Ball Bearing* CATALOG

Write for Form 1543

MARLIN-ROCKWELL CORPORATION

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KOLLSMAN
PRESSURE RATIO
THRUSTMETER
used on
Convair's F-102
McDonnell's F-101

which way* to measure jet engine performance?

THRUSTMETERS

to indicate PRESSURE RATIO
to indicate DIFFERENTIAL PRESSURE

TYPICAL SYSTEM – OPERATIONAL DATA

1. Accuracy: .015 in 100% of readings at room temperature.
   .025 in 85% of readings at −55°C and +70°C.
   .035 in 15% of readings at −55°C and +70°C.
2. Altitude: No specific limitation.
3. Power: 115V, 400CPS, single phase, 18VA
4. Pressure Ratio Range: 1.2 to 3.4
5. Pressure Ranges (operating):
   Pt_2=2 to 50" Hg. Abs.
   Pt_7=2.4 to 100" Hg. Abs.
   Pt_7-Pt_2=0.4 to 70" Hg.
6. Temperature Range: −55°C to +70°C.
7. Weights:
   Transmitter: 2.2 lbs.
   Indicator (including integral amplifier): 1.8 lb.
8. Response: Full Range in 7 seconds.

Actual photograph

KOLLSMAN is in production...

on components for BOTH TYPES — for Remote or Direct reading

For over a quarter century, Kollsman has been making precision pressure sensitive mechanisms using displacement type diaphragms. This diaphragm can be called the heart of a thrustmeter pressure indicating system.

Our long experience making displacement type diaphragms guarantees reliable thrustmeters.

Proven Kollsman displacement type diaphragms, when fitted with Kollsman Synchrotels, comprise the transmitters for remote indicating types. Thousands of Synchrotels are now in use in other applications equally demanding of accuracy and durability.

Tailor-made Thrustmeters can be supplied for any engine-airplane combination. Write for complete technical information.

**The Pressure Ratio System has advantages for indicating optimum climb and cruise throttle setting, whereas the Pressure Differential System has a definite advantage at take-off.*

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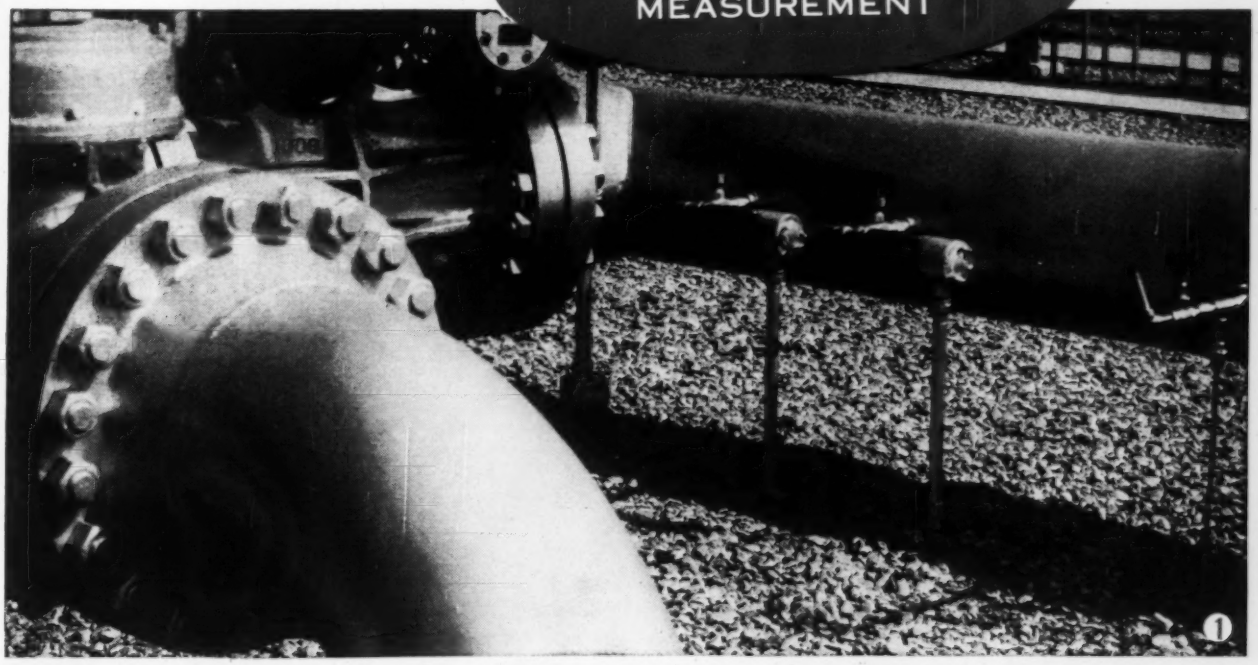
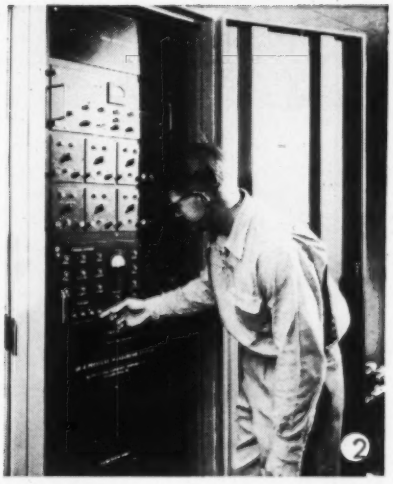
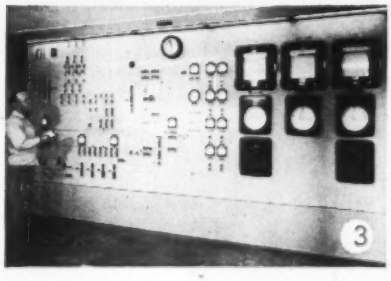
PACKAGED PRECISION MEASUREMENT







Pressures from SR-4 cells installed on suction and discharge lines at all ten stations (Photo 1) are channeled through the Baldwin console which is the brains of the remote pressure indicating system (Photo 2) to a master control panel (Photo 3) which shows at a glance pressure readings at all points.

A leading pipe line company reports:

"Corrosion-proof Baldwin SR-4® Pressure Cells let us measure remotely all pumping along 670-mile 'Big Inch'"

Reports a leading pipe line company: "We're using safe, accurate, corrosion-proof SR-4 Pressure Cells to control remotely all pumping along a new 22 inch crude oil pipeline. This 670-mile pipeline uses ten pumping stations, all controlled remotely through a telemetering system out of one control station hooked up to SR-4 Pressure Cells at each of the other stations. The SR-4 System gives us these important benefits:

"High Accuracy—Their dependable accuracy makes frequent calibration of the SR-4 Pressure Cells unnecessary. They are not affected by pressure pulsations of the pumps.

"Remote Indicating—Remote indicating SR-4 cells make it possible to control all ten stations through one.

"Corrosion Protection—The SR-4 cells are corrosion-proof preventing costly replacement and maintenance shutdowns of the lines.

"Explosion-Proof—The SR-4 cells have no moving parts to create a friction-spark fire hazard."

You, too, will profit many ways when you use accurate, dependable *Baldwin Packaged Precision Measurement* . . . for any pressure, load or torque measuring application. Send today for our illustrated bulletins that tell you how. Write to Department 3215, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

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March 21-24

The Radio-Electronic SPECTACULAR of 1955!

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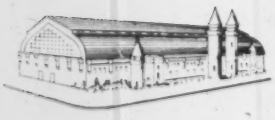
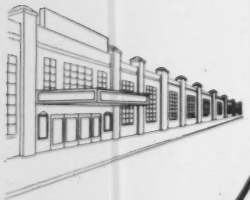
IRE National Convention

and

Radio Engineering Show

At both the Waldorf-Astoria (convention headquarters) and Kingsbridge Armory, you'll attend what actually amounts to 22 conventions fused into one. Hundreds of scientific and engineering papers will be presented during the many technical sessions, a large number of which are organized by I R E professional groups. You'll meet with the industry's leaders—enjoy the finest meeting and recreational facilities in New York.





At the Kingsbridge Armory and Kingsbridge Palace, you'll walk through a vast panorama of over 700 exhibits, displaying the latest and the newest in radio-electronics. You'll talk shop with the industry's top manufacturers—enjoy the conveniences provided for you in the world's finest exhibition halls, easily reached by subway and special bus service.

Admission by registration only. $1.00 for I R E members, $3.00 for non-members. Social events priced extra.

The Institute of Radio Engineers
1 East 79 Street, New York

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7 out of 704* good reasons why you should attend the Radio Engineering Show

Hear...

vital research and engineering papers on computers, transistors, color TV, etc., subject-organized in 55 sessions.

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a computer balance a cane, making 20 corrective moves a second—at the IRE Show.

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"1955 Instrumentation" shown on Instruments Avenue. Exhibit grouping helps you see more on the Avenues named.

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Meet...

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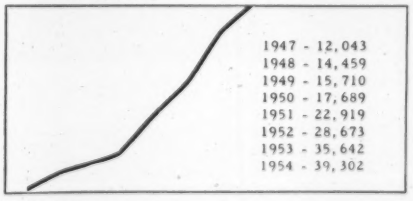

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The Convention's Social Events. It is good to mingle with your industry friends at IRE.

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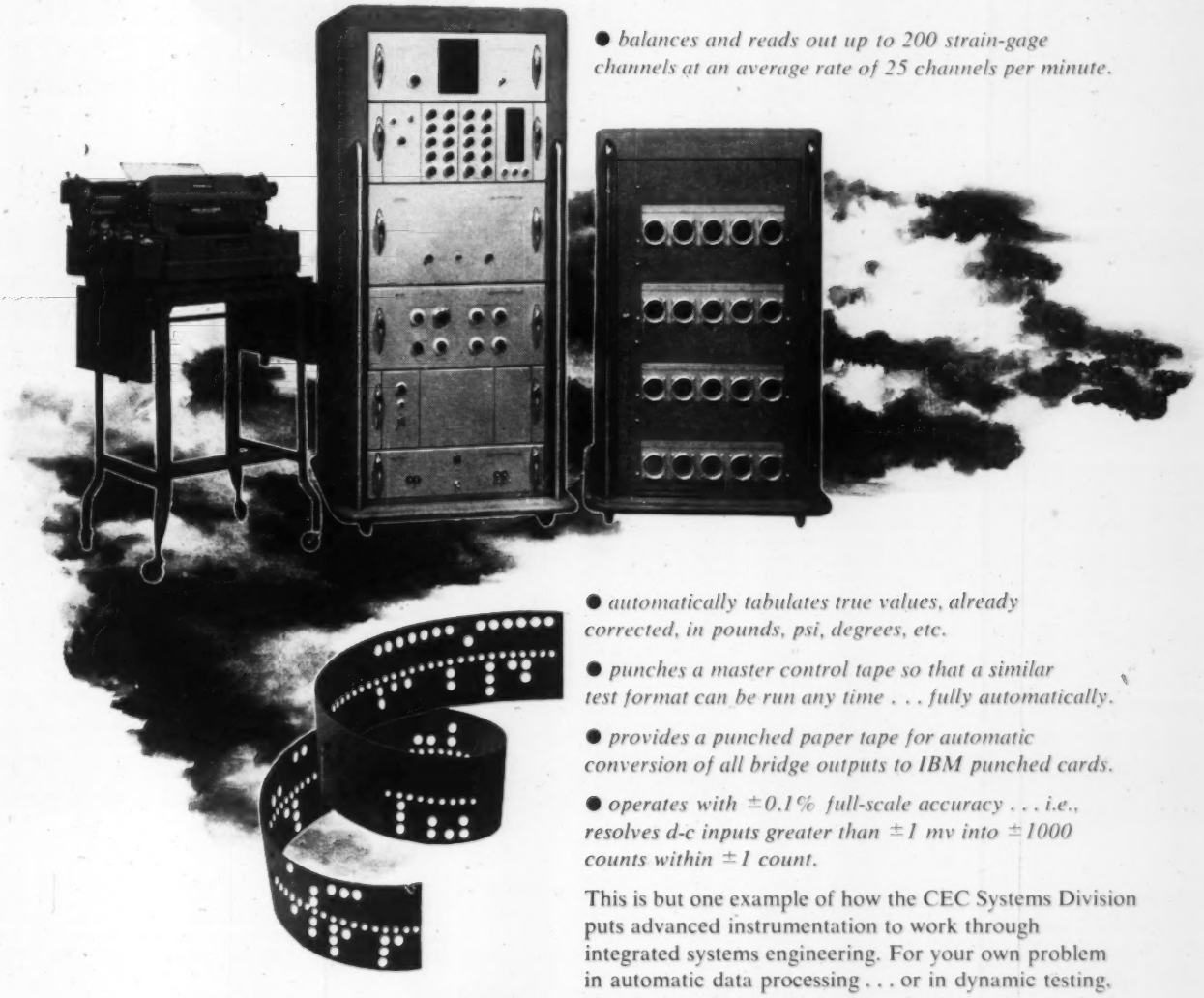
Oil refineries and wind tunnels have this in common: both involve a "process" containing three basic ingredients . . . first, a raw material . . . second, operations which change the raw material . . . third, a final product. And both must be controlled. Our job at CEC is to make that control as automatic as possible . . . whether the raw material is crude oil or information.

Recently we built a system (shown below) for automatic control of information at a major aircraft company in Georgia. The "raw material" is a series of electrical signals from test measurements . . . the "product," a tabulation of these measurements in immediately usable, numerical form. Here are just a few of the system's unusual features . . .



- *balances and reads out up to 200 strain-gage channels at an average rate of 25 channels per minute.*
- *automatically tabulates true values, already corrected, in pounds, psi, degrees, etc.*
- *punches a master control tape so that a similar test format can be run any time . . . fully automatically.*
- *provides a punched paper tape for automatic conversion of all bridge outputs to IBM punched cards.*
- *operates with ±0.1% full-scale accuracy . . . i.e., resolves d-c inputs greater than ±1 mv into ±1000 counts within ±1 count.*

This is but one example of how the CEC Systems Division puts advanced instrumentation to work through integrated systems engineering. For your own problem in automatic data processing . . . or in dynamic testing, chemical analysis or process monitoring and control . . . it will pay you to talk to CEC, to learn how *systems engineering* can go to work for you. Send today for Bulletin CEC 1304-X5.

Systems Division

Consolidated Engineering Corporation

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In figuring out new systems of automatic electrical control, Veeder-Root *Count*rol can supply vital connecting links. For instance, this Predetermining Counter can be hooked into such a system to light a light, ring a bell, or actuate a mechanism to stop a machine or process *at any pre-set point.* And there are many other Veeder-Root Counters that can serve as "countponents" in almost any way desired. Or special counters can be designed for specific applications. Engineers in any industry, now engaged in working out automatic control systems, can count on Veeder-Root engineers to work with them on any problem where reliable facts-in-figures are needed.

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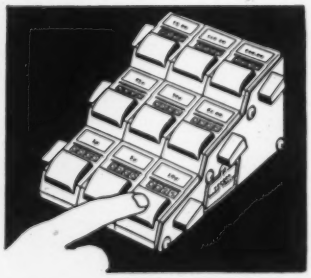
"The Name That Counts"



New *Vary-Tally* Multiple-Unit Reset Counter comes in any combination up to 6 banks high, and 12 units wide. Write for news sheet and prices.

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This Bailey Armortube* Cable can save you time and money

With this new material especially designed for pneumatic connecting lines you can make better instrument and control installations in less time and at less cost. Here's why:

Simple

Standard ARMORTUBE* cable is stocked in three convenient sizes: bundles of four, eight, or twelve ¼ inch O.D. aluminum alloy or copper tubes. Other sizes are available on special order. It's a ready-made, fully protected piping material for transmitting pneumatic signals between measuring units, instruments, and control units.

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The flexible metallic covering guards against every hazard, internal or external. Patented rope-like arrangement of tubes eliminates danger of collapse at sharp bends—and damage from external blows or vibration is minimized by protective outer covering.

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All necessary lines can be snaked through tight quarters or around corners with a minimum of connections. No need for unsightly, bulky channels, racks or other special mountings.

Economical

Installation is fast. 100 foot coils and 500 foot reels permit long unbroken runs. Colored tracer simplifies connections at terminals. Slightly higher first cost is quickly amortized by savings in materials, and installation time. For further information and specifications ask for Bulletin and Price List G91-9.

P-30

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INSTRUMENTS AND CONTROLS

For Power And Process

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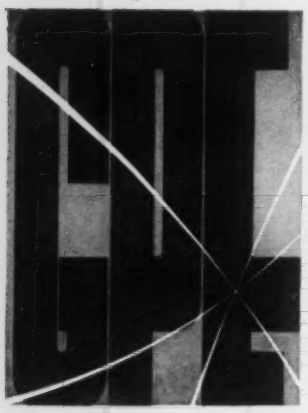

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The producing companies of General Precision Equipment Corporation are engaged in the development, production and sale of advanced technological products. These products all have a broad common base: 1) they represent precision equipment in some form; 2) they derive from similar fields of technical competence; 3) they save labor, increase productivity, or achieve results which cannot be attained with even limited use of on-the-spot manpower.

A general view of the technical capacities of the GPE Producing Companies is given in the chart. But the chart cannot show the very close interrelation of these capacities nor the highly flexible application of facilities, techniques and capabilities which exists among these companies. This is achieved through GPE's basic operating policy—Coordinated Precision Technology.

GPE Coordinated Precision Technology operates in all areas—in research, development and manufacture. The record of the GPE Producing Companies in solving advanced technological problems and meeting the demand for high speed, precision, reliability, light weight and compactness at competitive prices is the result of this coordination, the constant application of the newest and most highly advanced techniques, and unremitting insistence on highest quality.

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- MOTION PICTURE and SOUND EQUIPMENT
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Over **2200** scientists, engineers, draftsmen, testers and other technical personnel in the GPE Companies work in the fields covered by this chart.

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One of a series telling
how the producing companies of
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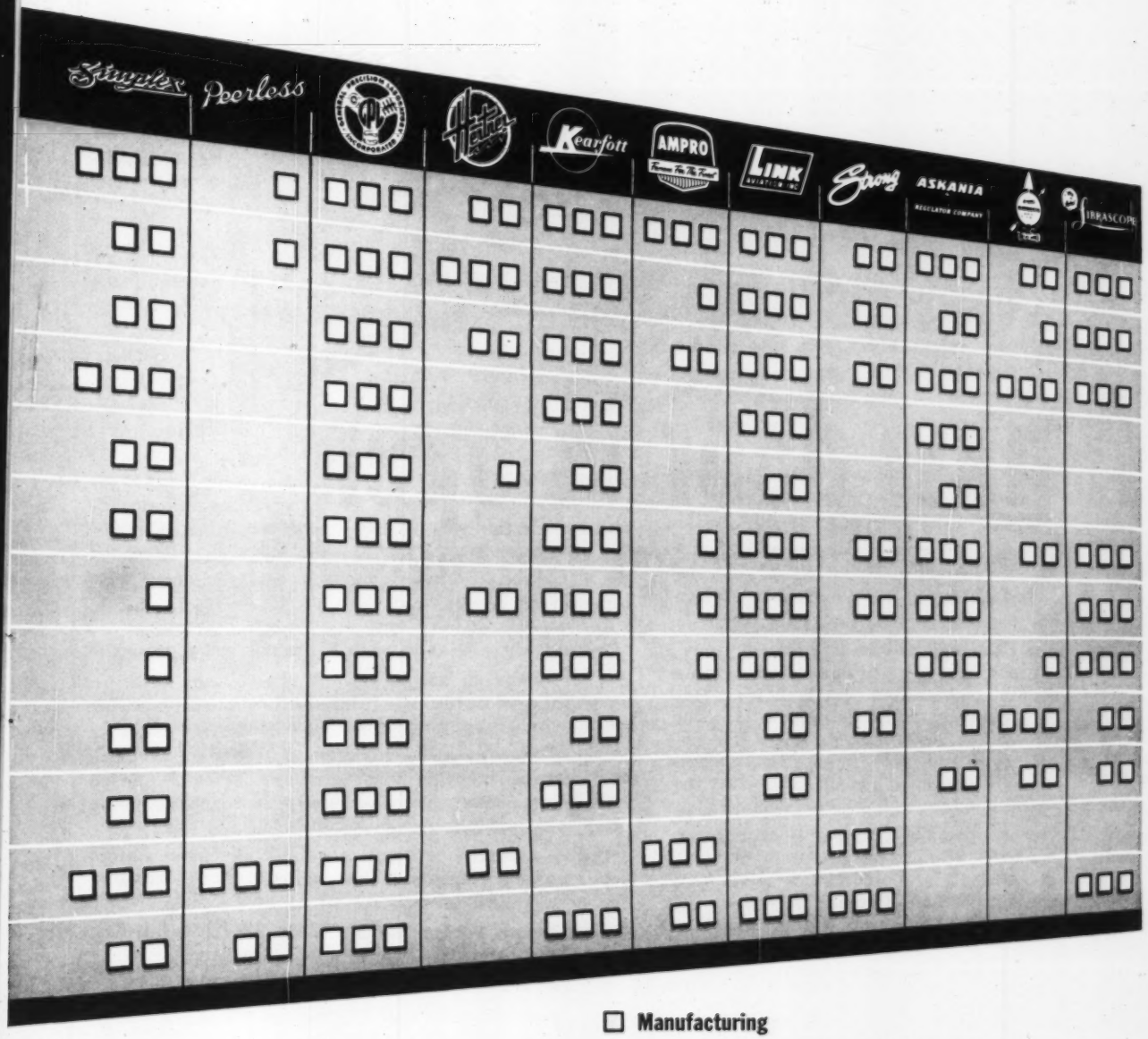
precision technology



□ Manufacturing

□□ Manufacturing and product development

□□□ Manufacturing, product development and research

□□□ Pilot manufacturing, product development and research

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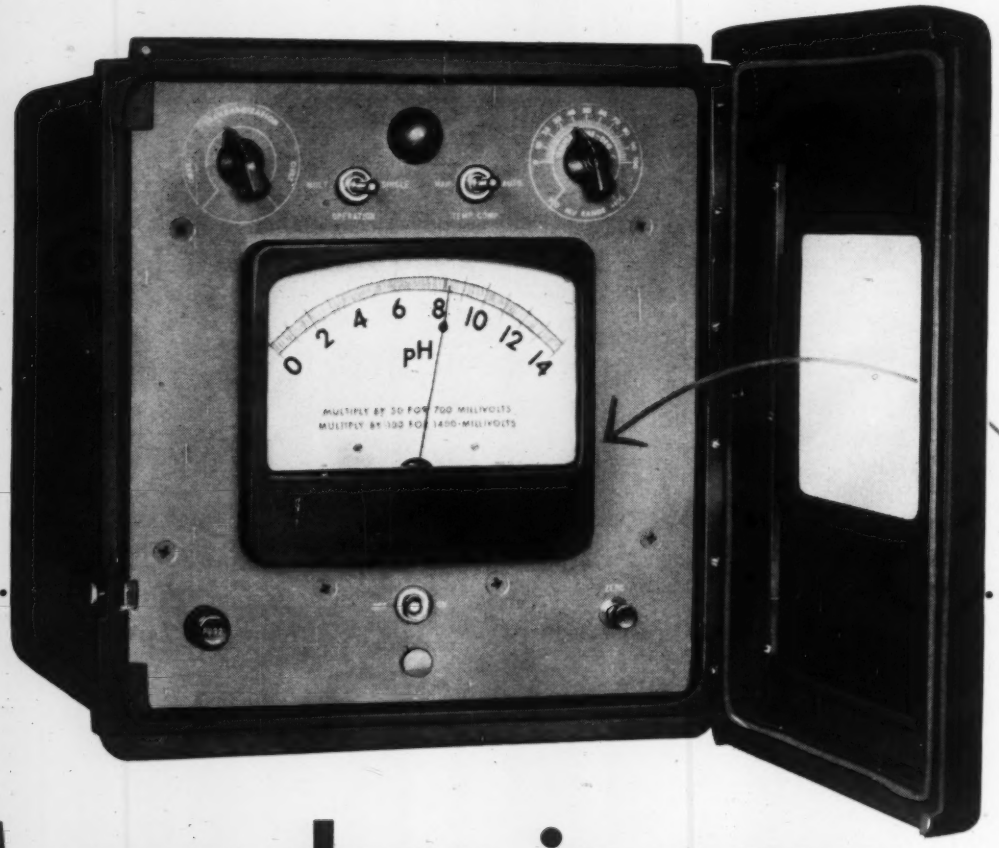

A new door is open

TO pH & REDOX INSTRUMENTATION

Here's the modern approach to process pH—a continuously measuring Panel-Mounted pH Indicator. This timely industrial version of our widely accepted Stabilized Bench-Type Indicator gives a 24-hour-per-day check on pH *or redox* with the same 0.02 pH accuracy as its lab-type counterpart.

The versatile Indicator offers a number of monitoring possibilities. Primarily a point-of-measurement indicator, it can also actuate remote meters (scale and pointer only) or a simple potentiometer recorder. Or, several Indicators, spotted through the process, can indicate locally and feed their respective values to one multiple-point Speedomax® recorder.

ONLY L&N BUILDS THESE STANDARD FEATURES IN A PROCESS pH INDICATOR

Low warm-up time of less than 1 minute for accurate readings. No de-humidifying period to wait. No desiccants required.

Unaffected by "error-inducers" such as line voltage surges, electrical pick-up, and zero drift.

No modifications in grounding system needed to measure grounded or ungrounded solutions.

Completely enclosed case keeps out water or corrosive fumes.

Manual and automatic temperature compensation in one Indicator. Switch to either as desired.

Simple maintenance by operating personnel. Conventional wiring with printed components makes service items inexpensive and easy to install. Entire chassis can be changed in only 60 seconds.

Highly accurate without recourse to external meters or recorders. Design takes advantage of exclusive features of L&N electrodes.

0 to 14 pH range in 0.1 pH div. 0 to 700 mv. in 5 mv. div., and 0 to 1400 mv. in 10 mv. div.

Die cast aluminum case only 12″ x 11″ x 11″.

List numbers—7678 (115 v., 50 to 60 cycles); 7679 (230 v., 50 to 60 cycles).

For details, write to Leeds & Northrup Co., 4955 Stenton Ave., Phila. 44, Pa., for Data Sheet ND42-96(1).

LEEDS [N] **NORTHRUP**
instruments *automatic controls • furnaces*

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Guest Editorial—

INDUSTRIAL INSTRUMENTATION in our ECONOMY

by **RAYMOND E. OLSON**

President, Taylor Instrument Companies

STORY of "Industrial Instrumentation in Our Economy" is a story of *growth*—growth in quantity of output, growth in engineering research and development, growth in acceptability by industry. Most of this growth has occurred within the past twenty years.

Twenty or twenty-five years ago resistance to the pioneering efforts of instrument advocates was strong. Practical, hard-headed businessmen found it easy to dismiss their "gadgetry" as "unnecessary expense." What a different picture we have today! Process instrumentation now is accepted as an absolute economic necessity!

How has the change come about? What are the underlying forces from which our industry derives its great vitality today? In attempting to answer these questions we should briefly review some of the reasons for the greatness of the American economy because we not only help account for its greatness, but we are all sustained by its greatness.

Our living standard, the highest in the world, is the result of the free, competitive enterprise system at work. The basic concepts of free enterprise—the right to work when and where you please, the right to make and keep a profit, the obligation to overcome obsolescence, the compulsion to experiment, and the privilege of running a risk—win, lose, or draw—these concepts coupled with *work* are the causes of economic greatness which the rest of the world sees and studies, but never quite believes.

What keeps this remarkable system going year after year?

Profit, particularly profit reinvested in the tools of production, is one major factor. In 1953 our output of goods and services was $367 billions, $60 billions of which was plowed back to replace resources and capital equipment.

Back in 1851, the year our company was established, the estimated work energy output of the country was 12 billions of horsepower-hours. Today it is estimated to be in excess of 400 billions of horsepower-hours. In 1851, 73 percent of the energy output was supplied by animals and human beings. In 1954, only 5% of the energy output was supplied by animals and human beings, and *the rest was supplied by tools of production.*

Yet, despite the vastly reduced use of man's muscles, employment exceeds 60 million people. In the chemical and oil industries today each employee commands approximately $50,000 in equipment.

Automation

This leads us to a consideration of what has been described as a new force at work in the nation's economy—"automation." Although the word is new, those of us in the process and instrument industries hear familiar ideas in every definition of the word. In our recent annual report to stockholders we described automation as "the automatic evaluation, recognition and resolution of a problem of industrial processing." We went on to point out that instrument people make a distinction between mechanical automation (the automatic factory) and process automation. The latter is the long-time, special preserve of the instrument industries working in conjunction with processors.

One could cite many examples, embracing all industries, of the contributions of process instrumentation to our economy. The more such information is disseminated the greater can be our rate of progress in further raising our living standards.

Industrial process instrumentation is one of the most vital production tools at the disposal of American industry. Although instrument manufacturers by their own enterprise have made possible the availability of constantly improved devices, the process industries can claim well-deserved credit. Their never-ending insistence on instruments of greater reliability and usefulness, and devices to measure and control new process variables, has been stimulating. Furthermore, it is the user who by sympathetic understanding, cooperation and the willingness to share in a calculated risk, has provided a real incentive for instrument manufacturers to strive to offer products of continuously improved performance and versatility. It can be predicted that the industrial instrument industry will continue to solve the problems which lie ahead, working in cooperation with the designers and operators of the processes of the future.

Peter F. Drucker, Professor of Management at the New York University Graduate School of Business, writing in *Dun's Review and Modern Industry* says: "I believe that automation will not inundate us in a sudden flood, but will seep in gradually though steadily. There can be little doubt that the first country to understand and apply automation systematically will lead in productivity and wealth during the second half of the twentieth century, just as the United States through understanding and applying mass production led the world during the earlier half century."

The "seeping process" has long since begun. The instrument industry "understands and is applying automation systematically." The instrument industry is already making sure that "the United States will lead in productivity and wealth during the second half of the twentieth century."

Abstracted from a talk delivered before the 10th Annual Symposium on Instrumentation for the Process Industries, Texas A&M, College Station, Texas.

New Instruments...

INSTRUMENTS and AUTOMATION

For further information use the postage-free order card on page 323

PROCESS CONTROL and MONITORING

On-off Controller

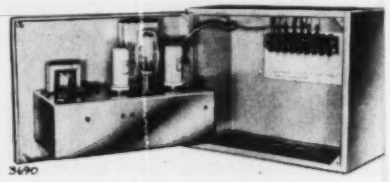
New "Model 360 Meter Controller" converts almost any electrical indicating or recording instrument into an

automatic controller or monitor; features isolated d-p.d-t. output relay contacts, signal lamp, and all necessary adjustments.—*Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.*

For more information circle **201** on inquiry card.

On-off Controller

New "Microlimit-controlled Electronic Load Relay" was developed for severe service conditions such as operating auxiliary equipment on rolling mills in synchronization with passage



of strip, plate and rod. It is easily adjusted by rolling mill operator under varying conditions of load, cold start, temper passes, and so on. It does not "load" circuits; will not burn out with overload; can be connected readily to existing equipment across instrument shunt without disturbing accuracy of instrument.—*Industrial Gauges Corp., Englewood, N. J.*

For more information circle **202** on inquiry card.

Electronic Totalizer

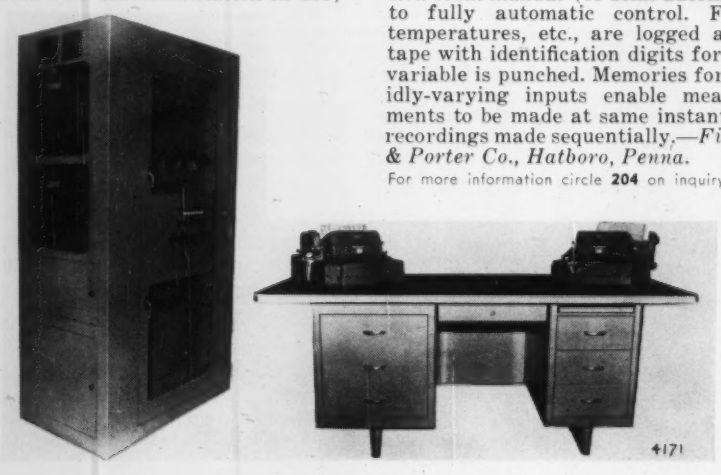
New "Model 21" digitizes output signal of any primary device producing output of 10 mv. or more, at frequencies up to 1000 cps.—*Potter Aeronautical Co., Union, N. J.*

For more information circle **203** on inquiry card.

Industrial Process Data-handling System

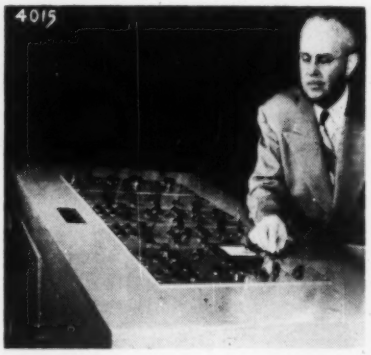
New "Automatic Logger" can be integrated with instrumentation in use; was developed for economical transition from manual (or semi-automatic) to fully automatic control. Flows, temperatures, etc., are logged and a tape with identification digits for each variable is punched. Memories for rapidly-varying inputs enable measurements to be made at same instant and recordings made sequentially.—*Fischer & Porter Co., Hatboro, Penna.*

For more information circle **204** on inquiry card.



Power Station Control

New control system for power stations uses electronic controls to regulate plant's output and frequency in



accordance with electrical demand changes. Signals to each station require only one channel. Individual servo units supervise three different control methods. System can be built into new or existing power plants, either steam or hydroelectric. It uses wire, carrier or microwave transmission.—*Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **205** on inquiry card.

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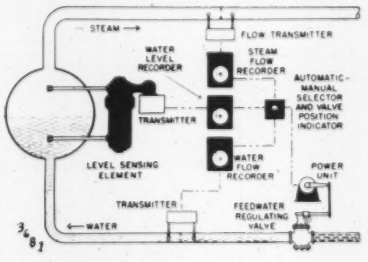
Feedwater Control Systems

New one-, two- and three-element feedwater control systems feature electronic null-balance operation controller providing high speed of transmission and close control unaffected by normal variations in voltage and frequency. Three systems meet requirements of large, medium or small boil-



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For more information circle **37** on inquiry card.

Circle **38** on inquiry card. →

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Error Spread Curve for a typical month's production of transmitters.

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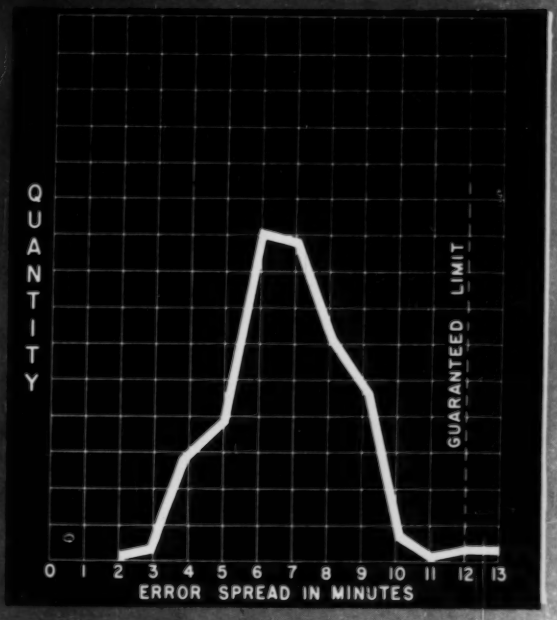
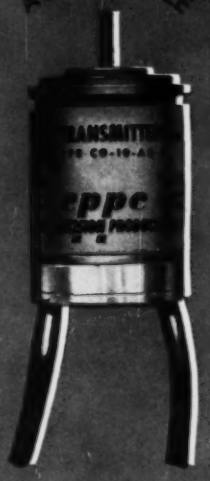
- Average RMS Error under 3'
- GUARANTEED Maximum Error Spread 12'



ACTUAL SIZE



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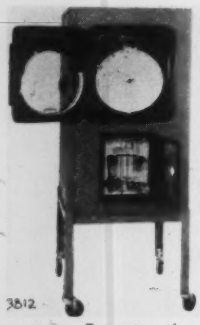
ers. Present instruments can be utilized and pressures up to 2,500 psig. can be accommodated. Shown here is the three-element system (level, steam flow and water flow).—*The Hays Corp., Michigan City, Indiana.*

For more information circle **206** on inquiry card.

Dissolved-oxygen Analyzer

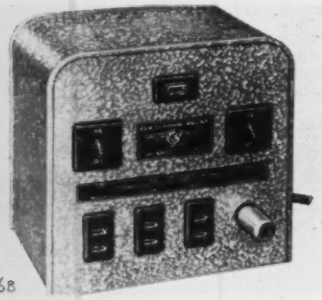

3812

New "Model 2B2B" continuously measures dissolved oxygen in boiler feedwater; comprises a sampler, an ion exchange unit, an analysis unit, and a modified recorder—on a mobile stand (as illustrated) or panel-mounted. Range 0-20 parts per billion adjustable to 0-200 ppb. Accuracy 5 percent of reading. Adjustable range is highly useful when leaks occur in system.—*Arnold O. Beckman, Inc., 1020 Mission St., South Pasadena, Calif.*

For more information circle **207** on inquiry card.

Control Station

New redesign of maker's "Electronic Relay Control Box" provides a better means of handling substantial

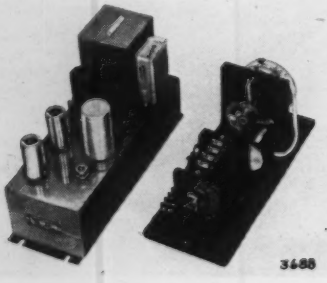

3868

power loads (up to 15 amps.) with minute currents (as low as 2 microamps) over contacts of regulating devices.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **208** on inquiry card.

Servo Multiplier

New "SL-1053" converts a d-c. input variable into a shaft rotation. A precision voltage-dividing resistor, driven by this shaft, performs computation. Three 2-megohm summing inputs for 1, 2 or 3 input variables. Over-all accuracy 0.3 percent; full-

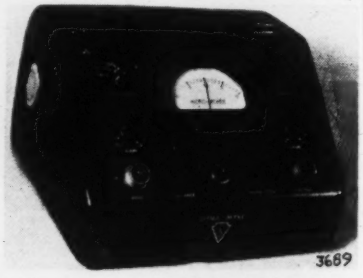

3688

scale travel under 0.5 sec.; response to 10 cps.; input zero drift negligible. Supplied as two or three basic packages, or built into a standard 19-in. rack panel. Output indication provided when required.—*Industrial Control Co., Wyandanch, L. I., N. Y.*

For more information circle **209** on inquiry card.

Measuring System

New "Model 129-E Dyna-Mike" (dynamic micrometer) is a "single-package control system" for inductive and resistive types of pickups (LVDTs,

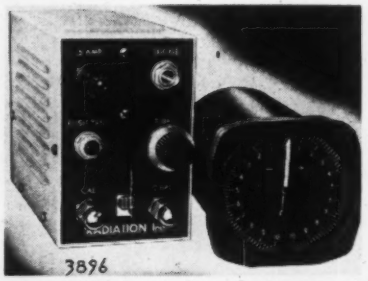

3689

strain gages, etc.). It includes all necessary a-c. and d-c. facilities for energizing, balancing and calibrating the pickups and for measuring steady or slow-changing lengths, forces, pressures, etc. For recording rapidly-changing phenomena, its output can be fed into an oscillograph. For automatic control applications, its output can drive a servomotor.—*Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.*

For more information circle **210** on inquiry card.

Amplifier and Indicator

New "R1040-6 Servometer" is designed for resistive bridge-type measuring elements such as pressure, load and acceleration pickups. Pickup output is amplified by a high-gain nonlinear amplifier, which drives a servo-

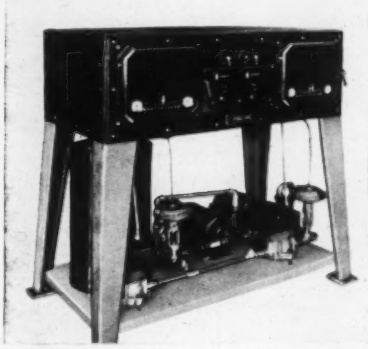

3896

motor within an aircraft type panel indicator. System has 0.5 percent full-scale accuracy over temperature range of –55 F. to 160 F., voltage range 105-125 volts, and frequency variations 300-450 cps.—*Radiation, Inc., Melbourne, Fla.*

For more information circle **211** on inquiry card.

Automatic Blender

New "Two Component Blender," complete "package" for on-stream



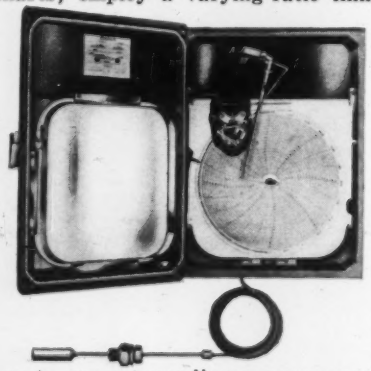
blending, automatically delivers a uniform blend directly to tank trucks, tank cars, ships or storage.—*Proportioneers, Inc., 345 Harris Ave., Providence, R. I.*

For more information circle **212** on inquiry card.

TEMPERATURE and COMBUSTION

Uniform-scale Vapor-pressure Thermometers

New vapor-pressure thermal systems record on uniformly-graduated charts; employ a varying-ratio link-

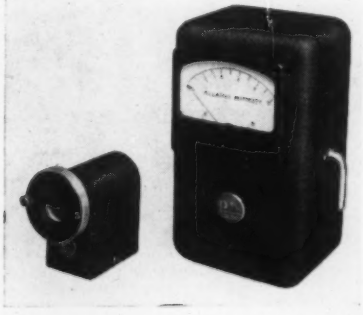


age to convert non-linear vapor-pressure *vs.* temperature curve into linear deflection of recording pen. Ranges from –20 to 600 F.—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **213** on inquiry card.

Photoelectric Pyrometer

New photoelectric pyrometer responds to infrared radiation; comprises two units: "Type 41AU4 Scanner" consisting of a phototube and lens assembly with a variable iris, and "Type 27LJ7 Control" containing an electronic amplifier, a relay and an indicating instrument. Temperature measuring and control range: 1000 to 5000 F.; sensitivity: one footcandle full-scale; relay characteristics: s-p.



NORWOOD CONTROLS Gyro Mass Meter. *To measure true mass flow directly, the flowing stream is sent through a pipe configuration so that the mass of material flowing corresponds to a rotating gyro wheel. When the gyro is precessed by rotating the pipe about the axis of flow, it provides a torque which is directly proportional to the mass flow of the material flowing through the pipe.*

lbs. not gals.

The inherent — and costly — inaccuracies in measuring flow by volume have long been recognized. But could a practical, economical way be found to provide meter accuracy which would be fundamentally independent of temperature, pressure, density and viscosity? The answer is now supplied by the NORWOOD CONTROLS Gyro Mass Meter which measures — or meters — flow by weight, not volume.

With the Gyro Mass Meter, accuracies of measurement are attainable for the first time that meet cost-accounting standards in a variety of continuous flow batching, blending, proportioning, bulk metering and process control applications. Since most of the commerce in bulk fluids is currently transacted on a weight basis, doesn't it make sense to use an instrument that measures *directly* in pounds or tons?

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Controls Division

CONTROL ENGINEERING CORPORATION

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Complete technical information will be supplied upon request

For more information circle **39** on inquiry card.

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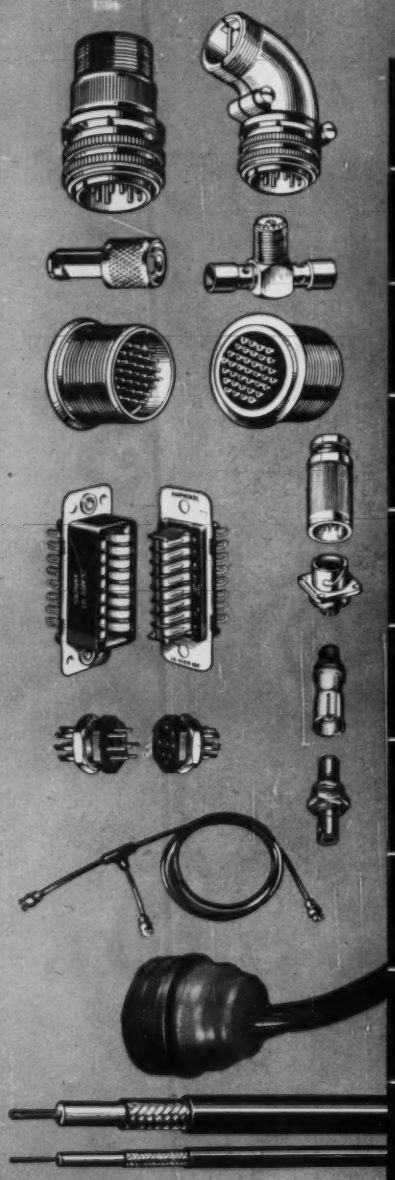

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NEW INSTRUMENTS

d-t. 10 amp. at 115 v., 5 amp. at 230 v. non-inductive.—*Photoswitch Div., Electronics Corp. of America, 77 Broadway, Cambridge 42, Mass.*

For more information circle **214** on inquiry card.

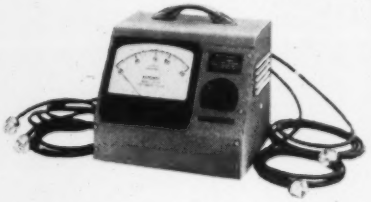
Fast-response Thermistor

New "Type L 118" thermistor, said to combine rapid response of smallest commercially-available model with extreme stability at high operating temperatures is a tiny glass-coated ceramic element (see photo). Previously, thermistors of this size were rated for a maximum continuous temperature of 150 C.; new type is rated at 300 C. where it is extremely stable, and is useful to 400 C. with good stability. One milliwatt will heat it more than 10 C. above ambient in still air.—*Thermistor Corp. of America, Metuchen, N. J.*

For more information circle **215** on inquiry card.

Thermistor Thermometer

New thermistor-type temperature indicator, shown here with four probes, can be obtained with more or fewer probes. Lead length can be



changed at any time without recalibrating instrument. Glass-beaded thermistors contained in sealed housings provide fast response to temperature changes. Instrument shown is calibrated from 65 F. to 85 F. and can be read to one-tenth degree. Battery check position is included on selector switch.—*Instrument Div., Avionic Products Engineering Corp., Dover, N. J.*

For more information circle **216** on inquiry card.

Cold-end Compensator

New device which makes it simple to change reference-junction compensators when going from one type of thermocouple to another (previously a tedious rewiring job) is now available on maker's "Electronic Dynamaster Multiple-Point Pyrometers." It is a small cylindrical aluminum piece with an opening in one end into which a compensating resistor can be inserted. All reference junctions are located in cylinder wall; extension wires necessary for all ISA-approved TCs are included, permitting use of any of these TCs with recorder with no cable changes. Instrument can also be used as a millivoltmeter. Because extension wires are not wired through multiple switch, it is possible to obtain extremely good compensation, whence high accuracy on low ranges.—*The Bristol Company, Waterbury 20, Conn.*

For more information circle **217** on inquiry card.

← Circle **40** on inquiry card.

Temperature Controller

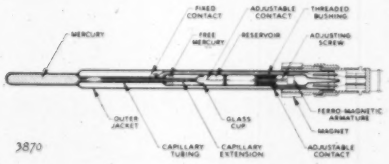
New "FulTrol" proportional-action temperature controller is of differential-expansion type; is suited for

use with compressed air, water or any clear low-viscosity hydraulic medium. Temperature ranges 50 to 250 F. and 150 to 350 F. (others also proposed). Proportional band adjustable between 5 and 25 F. deg. with ordinary screw driver.—*Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box* 400, *Knoxville* 1, *Tenn.*

For more information circle **218** on inquiry card.

Thermoregulator

New "Magna-Set" is a new type of mercurial thermoregulator said to have "an accuracy and sensitivity hitherto unavailable even in fixed-contact thermostats." Under favorable conditions, constant-temperature baths

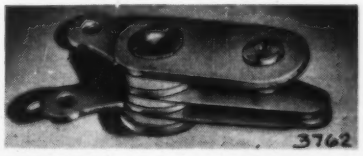


are controlled within 0.002 C. Unique design features: improved reservoir for displaced mercury used when making rough or preliminary adjustments; and variable electrode with magnetically controlled micrometer for fine adjustments. Temperature range of –35 C. to 300 C.—*Precision Thermometer & Instrument Co.*, 1434 *Brandywine St., Philadelphia* 30, *Pa.*

For more information circle **219** on inquiry card.

Appliance Thermostat

New "Type B" bimetal thermostat for use in table appliances, follows



general design and construction of "Type S" except that bi-metal thermal element is current-carrying.—*Stevens Mfg. Co., Inc., Mansfield, Ohio.*

For more information circle **220** on inquiry card.

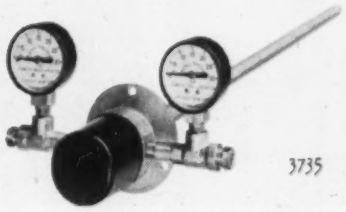
Thermoscopic Liquids

New "Tempilaq" suspensions for 413 and 438 F. have been added to maker's line of temperature-indicating materials. "Tempilaq" dries quickly, leaving a mat opaque coating which liquefies when temperature rating is reached.—*Tempil Corp.*, 132 *W. 22nd St., New York* 11, *N. Y.*

For more information circle **221** on inquiry card.

Temperature Controller

New "Limitem" non-bleed proportional-action pneumatic temperature controller is of differential expansion



type. Temperature range 35 to 135 F. Sensitivity can be adjusted from ⅛ to 2 psi. per deg. temperature change, gradual acting. Averaging bulb is 18 in. long with ⅜-in. pipe or flange connection.—*Dep't. IUP, The Powers Regulator Co., Skokie, Illinois.*

For more information circle **222** on inquiry card.

Temperature Controllers

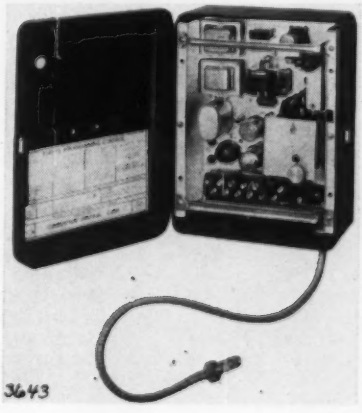
New "Amplitrol Model A" utilizes null-balance potentiometer principle but does not have to be standardized manually or automatically. Unbalance

emf. is fed to a saturable reactor, whose output controls firing or cut-off of a thyratron, which in turn opens or closes power relay. Differential between on and off points is approx. 4 F. deg. ★New "Model AP" (proportional action) is for applications conducive to "thermal inertia." Both models have automatic cold-junction compensation and thermocouple-break protection; both "fail safe."—*Thermo Electric Mfg. Co.*, 496 *Huff St., Dubuque, Iowa.*

For more information circle **223** on inquiry card.

Combustion Controller

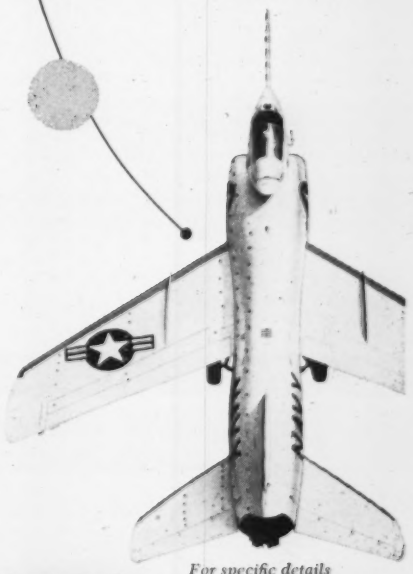
New "FJ-2 Fireye Combustion Control System" is said to give "a degree of safety previously available only with large industrial heavy oil burn-



spots instead of stripes for the tiger of the sky

The all-white prototype Grumman F9F-9 Tiger is polka-dotted with unpainted circles surrounding static pressure orifices. There are more than 250 of these points on the left side of the airplane.

The Navy's new supersonic jet fighter is instrumented with Statham Model P81 Pressure Transducers for determination of pressure distribution in flight.



For specific details pertaining to Statham Pressure Transducers, please request Bulletin No. PT-1.

Statham LABORATORIES

Los Angeles 64, Calif.

For more information circle **41** on inquiry card.

ers." It automatically programs start-up, operating, and shutdown cycle of burner, permitting unattended operation. Safe-start feature: component failure or presence of flame before startup prevents burner operation.—*Dep't CN, Electronics Corp. of America, 718 Beacon St., Boston 15, Mass.*

For more information circle **224** on inquiry card.

FLOW-RATE, VOLUME and LEVEL

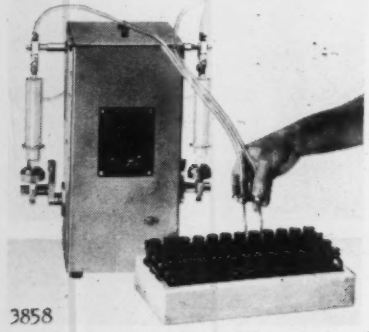
Stainless Steel Meters

New series of stainless steel "Rotocycle" meters for corrosive liquids includes 2-in. 100-gpm. and 3-in. 200-gpm. bulk plant models and 2-in. pipeline models. New features include a new optional meter-strainer arrangement and a new style temperature compensator which is a complete thermal system: bulb, tube, and—in meter head—bellows actuating a variable-speed device. An additional bellows in meter head responds to ambient temperature changes.—*Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.*

For more information circle **225** on inquiry card.

Vial Filler

New "Filamatic Model DAB" permits vials up to 50 cc. to be filled two



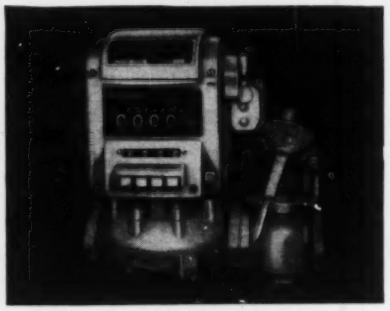
3858

at a time: up to 4800 fills per hour. Volume delivered can be varied from 0.03 to 50 cc. with accuracy of 1 percent.—*National Instrument Co., 5005 Queensbury Ave., Baltimore 15, Md.*

For more information circle **226** on inquiry card.

Preset-volume Meter

New "Auto-Switch Meter" features explosion-proof 15-amp. switch actuated when any desired quantity of liq-



uid has passed through meter. Available either with or without mechanically-coupled "Auto-Stop" valve likewise actuated by tripping mechanism in register. Register is set quickly by pushing buttons. Large numerals keep pace with flow and provide a visual check when delivery is finished. Smaller numerals register cumulative totals. Meter sizes 1-in. to 4-in. for rates of flow to 500 gpm.—*Neptune Meter Co., 19 W. 50th Street, New York 20, N. Y.*

For more information circle **227** on inquiry card.

Chart Integrator

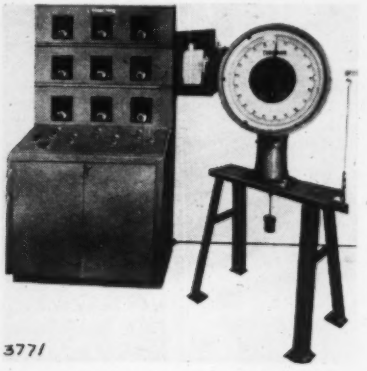
New model of maker's Integrator is electrically operated; features a counter setback assembly operating from main calibration post that enables operator to run practically all ranges of

charts at any base pressure, whence an almost infinite number of range settings (instead of limited number of range holes). When new integrator is in calibration for one make of orifice meter charts, it is in calibration for all makes of charts that it will calculate. Other advances include improved brake assembly; new cam shifting design; centers individually calibrated, etc.—*Rockwell Mfg. Co., 400 N. Lexington Ave, Pittsburgh 8, Pa.*

For more information circle **229** on inquiry card.

Batching System

New "Thurma-tronic" batching system for continuous process industries is adaptable to either accumulative or consecutive weighing. Controls may be



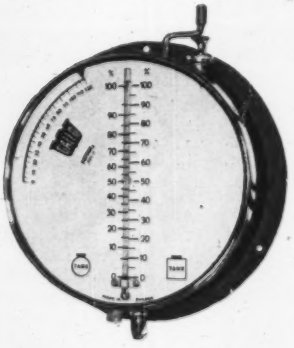
3771

set for weighing one batch, for completely automatic continuous batching, or for weighing any specific number of batches. System is unlimited in number of materials that may be batched in one formula; and any formula requiring change by batching operation can be quickly reset. Existing plants can be equipped with new system.—*Thurman Machine Co., Scale Div., 156 N. Fifth St., Columbus, Ohio.*

For more information circle **230** on inquiry card.

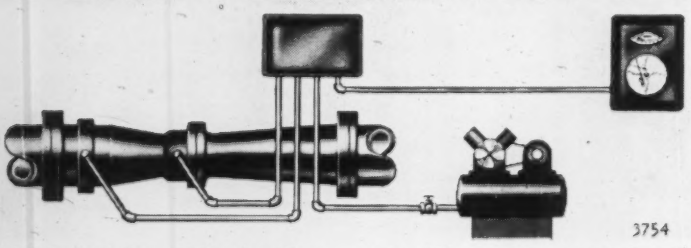
Tank Gage

New "Gallo" (made in Sweden) can be used without re-graduating on tanks of any size up to 11 ft. diameter (or height) and with liquids of any



specific gravity from 0.65 to 1.0 To use: After a few strokes of air pump, mercury height is read—on left side of tube if tank is circular and on right side if tank is rectangular or if it is a standing cylinder. Mercury tube is adjustable from vertical to plus 30 deg. inclination, with settings made according to an index scale at edge of

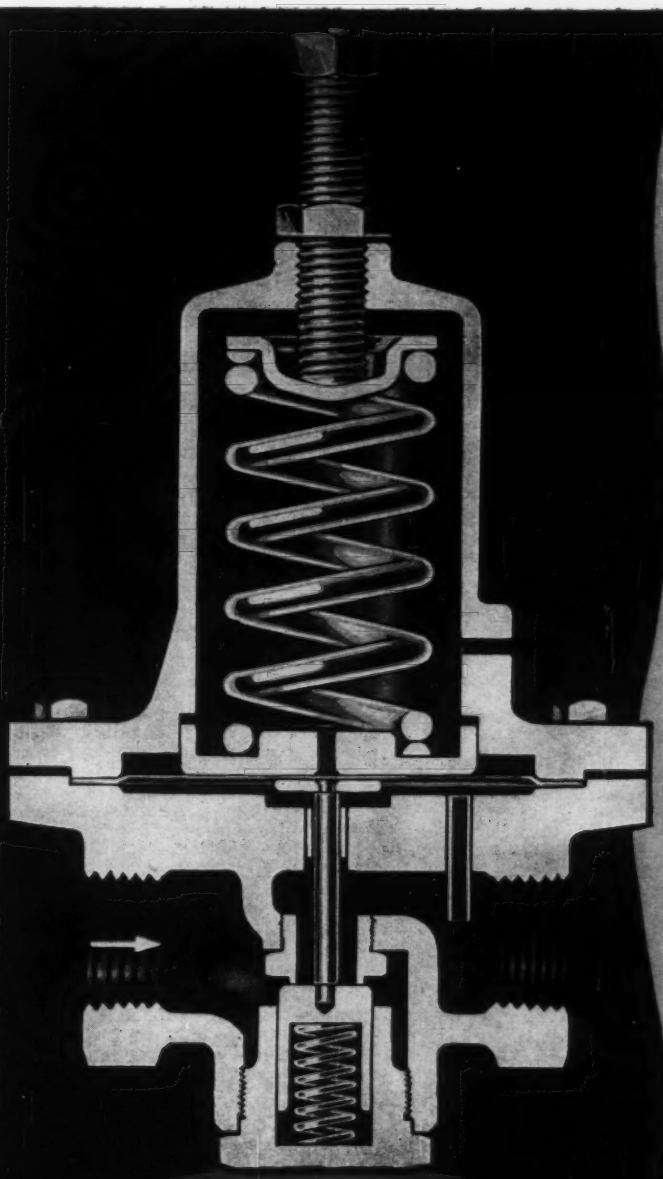
Remote Pneumatic Transmission System



3754

New "Laminair" permits locating instruments at great distances from primary devices without regard for hydraulic elevation difference. Two main assemblies: (1) differential converter; (2) bellows type receiving mechanism which translates air pressure into measurement for flow or pressure indicating or recording instrument. Air consumption for each converter averages only 0.1 scfm.—*Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa.*

For more information circle **228** on inquiry card.



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Series 95

SELF-CONTAINED PRESSURE REGULATOR

. . . A simple, sturdy, self-contained regulator that is suitable for steam, air, gas, oil, water and other fluids.

TYPE 95H features hardened stainless steel trim . . . flat seat . . . machine lapped seating surfaces for tight shut-off for high pressure, high temperature service.

TYPE 95L has soft seat construction for low temperature service.

Sizes: ¼", ⅜", ½", ¾", 1". Outlet pressures from 2 to 30 PSI; 15 to 150 PSI. Size for size, compare its capacity.

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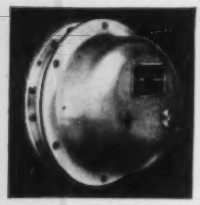
Our 75th ANNIVERSARY

For more information circle **42** on inquiry card.

dial. A change in tank dimensions or in specific gravity of liquid requires only a new setting of scale.—*Dep't 56, Way, Wolff & Associates, Inc., 33 Fulton St., New York 7, N. Y.*

For more information circle **231** on inquiry card.

Bin Level Indicator

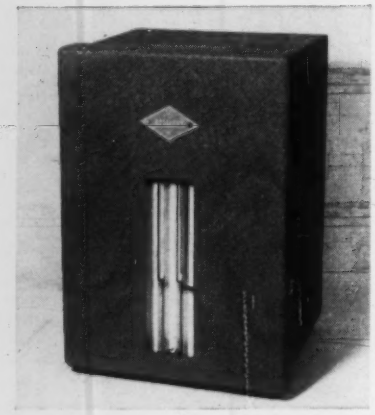


New "Model AL Bin-Dicator" incorporates a built-in bull's-eye signal light readily seen by an operator; comes completely assembled and ready for connection to user's power source; is as easy to install as standard models.—*The Bin-Dicator Co., 13946-201 Kercheval, Detroit 15, Michigan.*

For more information circle **232** on inquiry card.

Differential Level Indicator-controller

New "Model DL Belmont Differential-Level Monitor" utilizes bubble-tube principle, comprises a control

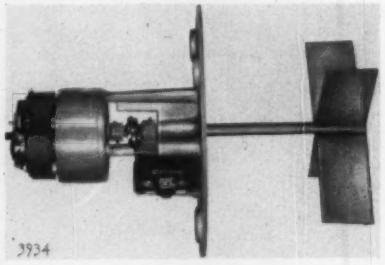


manometer and a relay-actuating electronic switch, also a metering-type air compressor. External equipment can be connected to relay on normally-open or normally-closed basis (up to 1 hp. directly).—*Thermo Instruments Co., 1310 Old County Road, Belmont, Calif.*

For more information circle **233** on inquiry card.

Bin Level Indicator

New "Bin-Vue" comprises a 1/200 h.p. motor turning at 5 rpm. connected to a shaft by means of a torsion spring. At end of shaft is a 4-blade paddle which, when touched by mate-

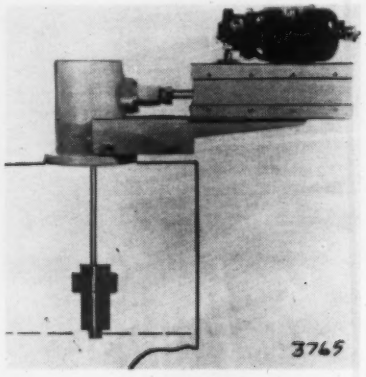


rial, stops; then spring actuates limit switch, which kicks out motor and actuates any other desired equipment. Spring is kept under torsion until material falls away and paddle turns spring away from limit switch and again starts motor.—*Convair Inc., 714 Brookline Blvd., Pittsburgh 26, Penna.*

For more information circle **234** on inquiry card.

Liquid Level Transmitter

New "Liquid Level Monitor" for local or remote continuous level indication, recording and control is all-electric; is suited to all vessels under vacuum or pressure; is unaffected by



ambient temperature conditions; works with all liquids regardless of chemical and/or liquid properties. Claimed accuracy is 1/16 in.—*Techniflex Corp., Port Jervis, N. Y.*

For more information circle **235** on inquiry card.

PRESSURE

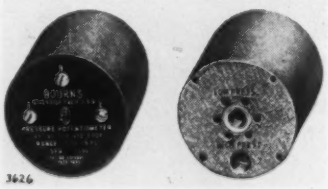
Pressure Pickups

New "Series M" medium-pressure and "Series H" high-pressure pickups replace earlier models in that every effort has been made to meet MIL-E-5272A. "Series M" units are for 0-50 to 0-4000 psi. ranges in which reference pressure (case) does not exceed 300 psi.; "Series H," for 0-50 to 0-4000 psi. ranges where reference pressures in excess of 500 psi. are encountered.—*Rahm Instruments, Inc., 12 W. Broadway, New York 7, N. Y.*

For more information circle **236** on inquiry card.

Differential Pressure Resistive Pickups

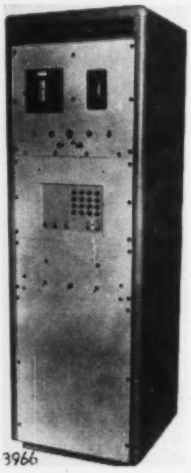
New "Model 508 Differential Pressure Potentiometer" operates under extreme temperature, shock, vibration and acceleration conditions. Resolution 0.25 to 0.50 percent for resistances from 1000 to 10,000 ohms. Specially-



developed beryllium copper capsule is exercised, tested and calibrated before assembly in pickup. Calibration certificate is supplied with each pickup.—*Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.*

For more information circle **237** on inquiry card.

Multiple Pressure Readout System

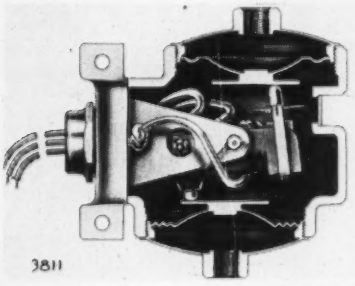


New "Automatic Press-I-Cell Logger" simultaneously samples up to 200 pressures with accuracy of one part in 2000 or higher, and digitally records them. Pressure magnitudes are automatically converted into digital form for recording as a typewritten column log and as a punched tape. Output may be fed directly to computers or card punch equipment without intermediate tape storage of data, when typewritten log is not required. Readout cycle (from pressure sensing to typewritten log and punched tape) is completed in a little over 60 seconds, and equipment is immediately in position to begin next cycle. Shorter readout cycles are possible.—*Fischer & Porter Co., Hatboro, Penna.*

For more information circle **238** on inquiry card.

Differential Pressure Switch

New "Meletron Model 462" will actuate an electric circuit on increase or decrease of any predetermined pressure difference between 0 and 99 psid. within range of switch selected (limits 0.05 and 100 psig.); is readily ad-



justed in the field; operates in any position; is functionally unaffected by jarring on mobile installations or by vibrations from pumps and compressors.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

For more information circle **239** on inquiry card.

Water-cooled Adapter for Pressure Pickups

New water-cooled adapter for standard pressure pickups is for pressure measurements at temperatures up to 4000 F.; available to receive maker's threaded or flanged pickups having sensitive diaphragms of 9/16-in. or ¼-

CLARE
Type J Relays
help count cars ACCURATELY and FAST . . . on Jersey's Garden State Parkway

Keeping track of traffic on the Garden State Parkway hour after hour, day after day, is rugged duty for control equipment. Only the most sturdy and precise components can stand the wear and tear.

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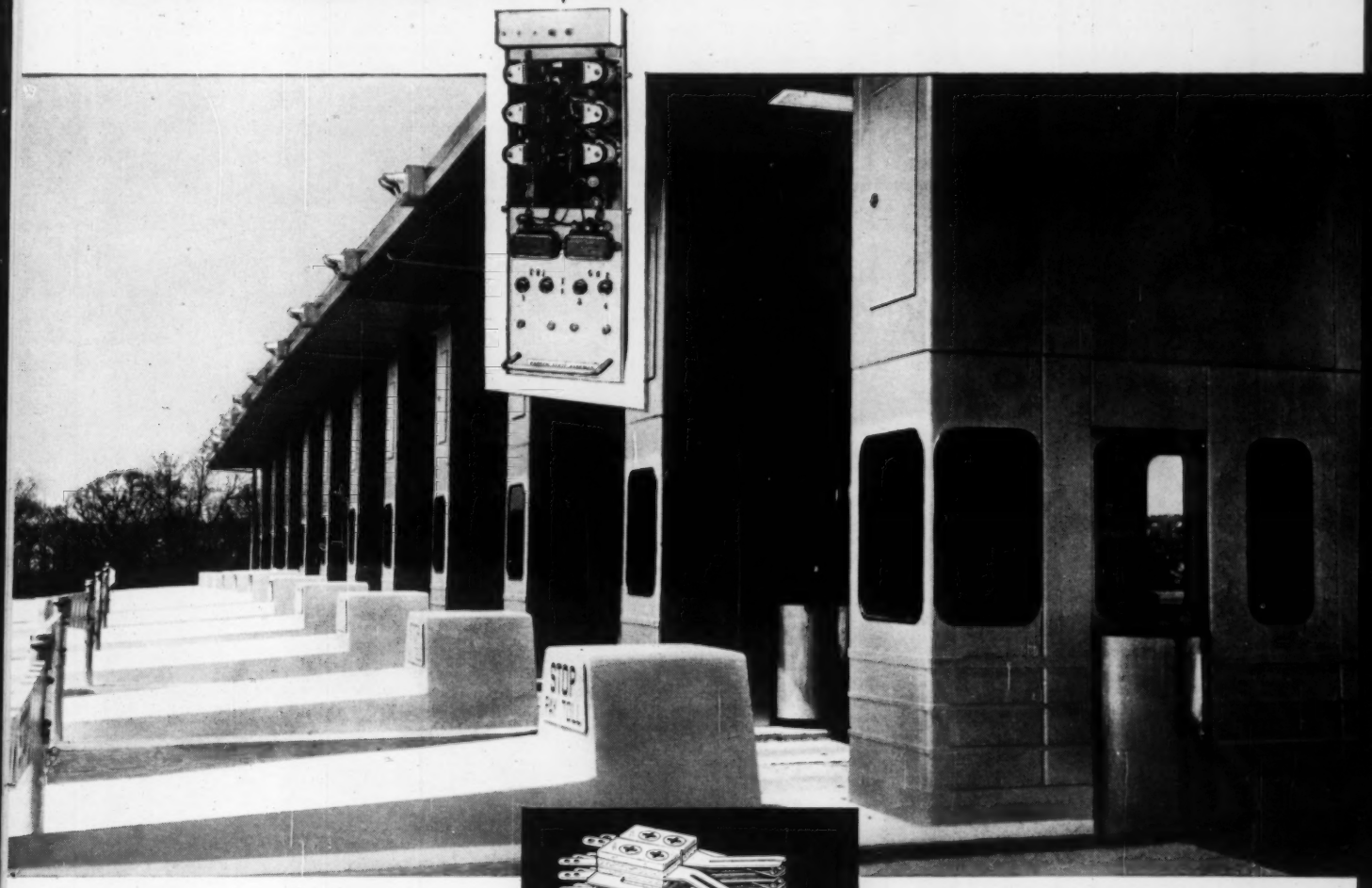
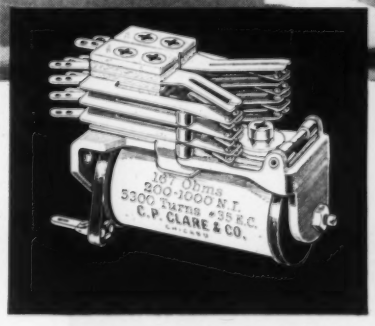




CLARE RELAYS

FIRST in the industrial field

For complete data on the Type J and all Clare Relays, write for ENGINEERING DATA BOOK. *A Clare sales engineer is located near you. Call him or write C. P. Clare & Co., 3101 West Pratt Blvd., Chicago 45, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address:* CLARELAY.

The Type J Relay may have just what YOU want in a relay

SMALL AND LIGHT:
2¼" long; 2¼ oz. (approx.)

LARGE CURRENT CAPACITY:
4 amperes, 150 watts. Twin contact points (palladium) standard.

FAST OPERATE-RELEASE:
1 to 2 milliseconds (Min.) Coils can be provided for time delay on operation, release, or both.

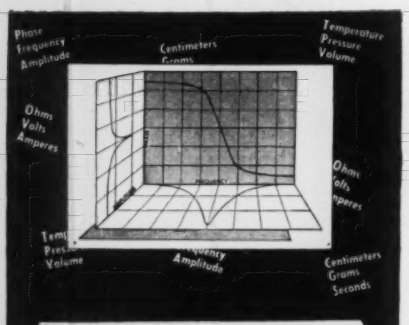
OPERATING VOLTAGE:
Up to 220 volts d-c.

NEW FEATURES:
Independently operating twin contacts minimize contact failure.

Hinge-type armature recently improved to prolong life and increase stability of relay adjustment.

New heavy duty yoke has stainless steel pivot pin with large bearing surface which turns in precisely reamed bearings of non-ferrous material.

For more information circle **43** on inquiry card.



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The familiar triads of measurement would not be complete without this important third dimension:

ACCURATE PHASE MEASUREMENT!

TIC, leaders in the field of Phase Measurement introduce —

THE TIC 322-A PRECISION PHASEMETER

By direct large scale and expanded scale meter readings, this highly accurate instrument displays absolute phase angle differences 0° to 360° between two voltages to an accuracy of ±1°, without ambiguity.

Large Direct Reading Meter: Scales 0°—360° and 0°—30°
Expanded Scale Operation in any 30° segment
Absolute Accuracy: ±1° for frequencies between 20 and 20,000 cycles, Slightly decreased accuracy 20,000 to 500,000 cycles
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Connection for Recorder: d-c output linear with phase angle

The 322-A Precision Phasemeter measures sine waves and non-sine waves having not more than one positive going zero axis crossing per cycle. For further information on this phasemeter, or any of the extensive line of phasemeters and standards, we invite your request.

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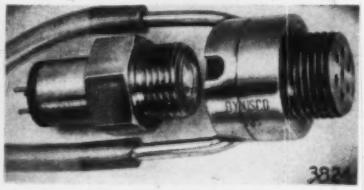
For more information circle **44** on inquiry card.

NEW INSTRUMENTS

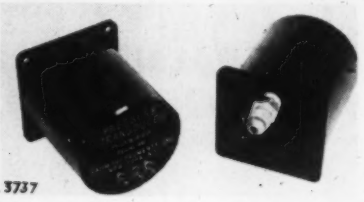


in. diam. Hot fluid is cooled in adapter tubes before it comes in contact with pressure pickup. Tubes are so short that pressure variations up to 3000 cps. are transmitted to pickup without appreciable phase shift.—*Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.*

For more information circle **240** on inquiry card.

Pressure Pickups

New "Series S" for 0-5 to 0-30 psi. ranges meet environmental and operating requirements of latest military



specs: use up to 160 C. (320 F.) and compliance with dynamic performance tolerances MIL-E-5272A.—*Rahm Instruments, Inc., 12 W. Broadway, New York 7, N. Y.*

For more information circle **241** on inquiry card.

FORCE—LOAD, WEIGHT, ACCELERATION

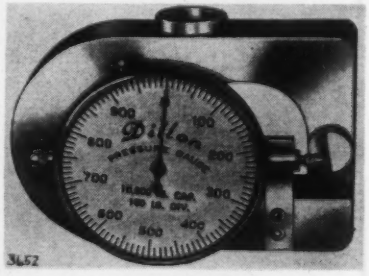
Tension Meter

New and improved trigger-type "Saxl Tension Meter" has, instead of previous models' pointer, a black line engraved in a transparent Lucite disk whose flywheel effect steadies readings even when winding on machines that have fluctuating tensions. However, a light-weight pointer is also provided to facilitate analysis of transients. New instrument will neither overstretch finest yarns nor allow insufficient yarn tensions.—*Tensitron, Inc., Harvard, Mass.*

For more information circle **242** on inquiry card.

Load Gage

New high-capacity model of "Pressure Gauge" measures loads to 10,000 lbs. with warranted accuracy of 1 per-

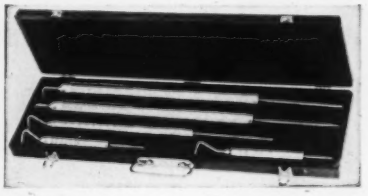


cent of indicated reading; will sustain accidental overloads of 25 percent without injury to calibration.—*W. C. Dillon & Co., Inc., P. O. Box 3008, Van Nuys, Calif.*

For more information circle **243** on inquiry card.

Force Indicators

New set of "Packaged Force Gauges for Horizontal and Vertical Measurement" consists of five gages chosen from a larger group ranging in capacity from 1 lb. by ¼ oz. to 40 lbs. by 8 oz. and 50 grams by 2 grams to 1000 g. by 10 g. Instruments have been re-

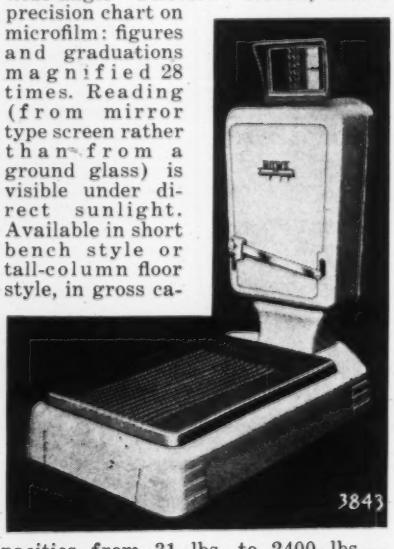


designed and may be used in all positions from pull-end down to push-end down.—*John Chatillon & Sons, 85 to 93 Cliff St., New York 38, N. Y.*

For more information circle **244** on inquiry card.

Projection-type Scale

New self-contained "Weightograph" has weight indication projected on a wide-angle "Teleview" screen; uses a precision chart on microfilm: figures and graduations magnified 28 times. Reading (from mirror type screen rather than from a ground glass) is visible under direct sunlight. Available in short bench style or tall-column floor style, in gross ca-



pacities from 31 lbs. to 2400 lbs.—*The Howe Scale Co., Inc., Rutland, Vermont.*

For more information circle **245** on inquiry card.

Acceleration Pickup

New "Glennite Perls-Kissinger Model A 450" wide-range barium titanate acceleration pickup (modified version of NBS design) has resonant frequency of 80 kc.; useful frequency

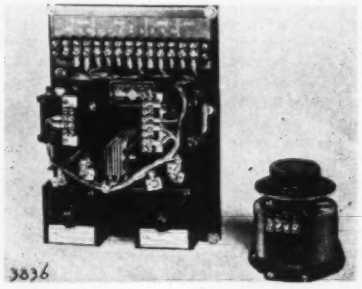
range of 10 to 25,000 cps; sensitivity 0.75 mv/*G* with a capacitance of 800 mmf. with 3 ft. low-noise cable.—*Gulton Mfg. Corp., Metuchen, N. J.*

For more information circle **246** on inquiry card.

SPEED

Motor Speed Controls

New stripped-down models of "Variac Motor Controls" obviate need of

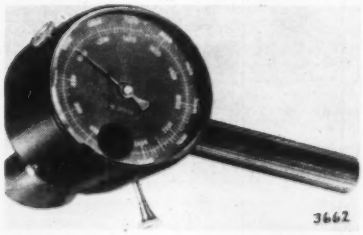


buying unwanted cabinets and switching. All sizes from 1/15 hp to 1½ hp. —*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **247** on inquiry card.

Stroboscope

New "Askania Hand Stroboscope" (German-made) for tachometry and for visual observation of periodic mo-

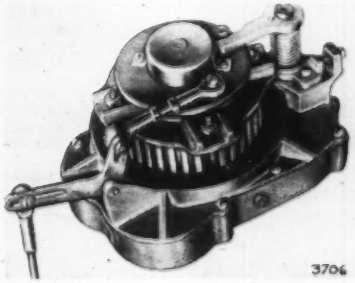


tions, does not require any electrical connection as it is operated by a spring motor. Range 400 to 12,000 rpm.—*Epic Inc., 154 Nassau St., New York 38, N. Y.*

For more information circle **248** on inquiry card.

Generator Governor

New "DUPY" electromechanical load sensing type governor controls speed of gas or diesel engine-driven generators; has two main functions:



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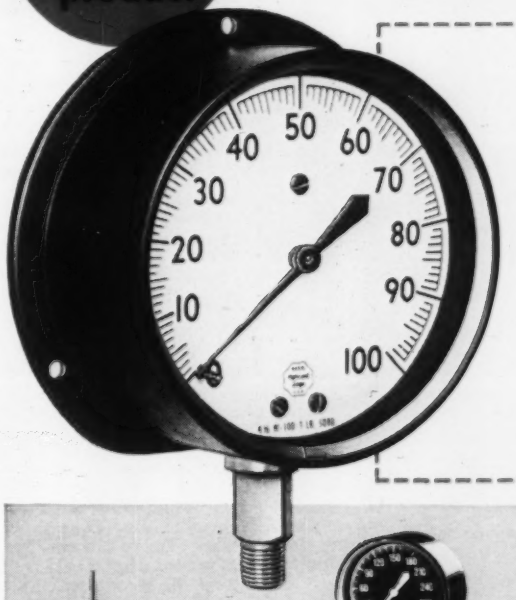
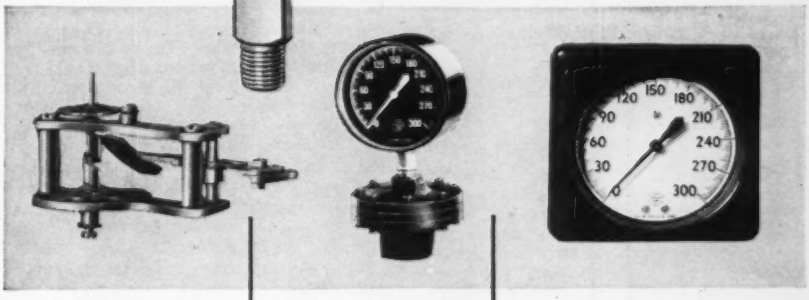
Helicoid Gages

gages for pressure, vacuum or compound service





Only Helicoid has the Helicoid movement.

Dials may be black, white or radiant.

Wall or stem mounting cases—flush, panel or flangeless cases.

Get the SUSTAINED ACCURACY only Helicoid can give

Everybody knows that the famous HELICOID movement outlasts a standard gear tooth movement. But did you know that Helicoid gage life is also tremendously increased by superior materials, methods and workmanship? Even the Bourdon tube in Helicoid gages is designed for maximum torque at minimum stress.

That is why Helicoid gages have exceeded 75,000,000 cycles at 1200 pulsations per minute. There is a Helicoid long-life gage to meet your every type of pressure indicating requirement. Ranges are to 20,000 p.s.i. and vacuum or compound.

Write today for the Helicoid G-2 Catalog

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AMERICAN CHAIN & CABLE

927 Connecticut Avenue • Bridgeport 2, Connecticut

Pressure • Vacuum • Compound

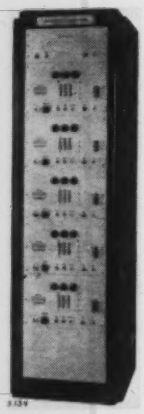
For more information circle **45** on inquiry card.

(1) controls frequency of an engine-driven a-c. alternator, (2) regulates voltage of a d-c. machine. Both functions are accomplished by controlling speed of prime mover.—*Inet Div., Leach Corp.*, 4441 *Santa Fe Ave., Los Angeles* 54, *Calif.*

For more information circle **249** on inquiry card.

TIME, SEQUENCE and PROGRAMMING

Multiple-sequence Timer



New "Model 3157 Multiple-Sequence Megacycle Preset Interval Generator" generates a series of preset time delays adjustable in increments of 1 usec. A 1-Mc. crystal-controlled master oscillator feeds one or more preset counters, each set to desired number of microseconds (up to 999) by selector switches. For sequential intervals or extended delays, output of one counter can be used to start another. "Model 3157" can be used also as a multiple-channel interval timer. Model shown has five separate timing channels. More or fewer channels can be provided.—*Potter Instrument Co., Inc., 115 Cutter Mill Road, Great Neck, N. Y.*

For more information circle **250** on inquiry card.

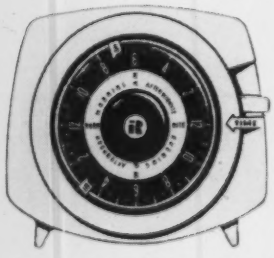
Process Timer

New model of maker's repeat cycle process timer (that operate continuously to turn circuits on and off for constant interval operation) now features percentage timing. Advantages are constant accuracy in repeated operation and reduction of strain on electrical components. New unit has a time cycle of 15 sec. to 24 hr. Immediate delivery.—*Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.*

For more information circle **251** on inquiry card.

24-hr. Timer

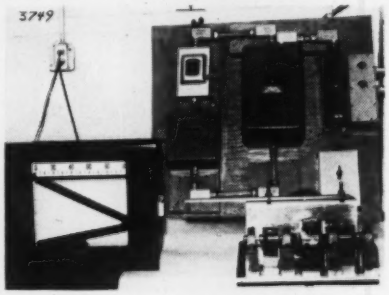
New 875-watt "Model A-221 Intermatic Time-All" is similar in operation to 1650-watt deluxe "Model A-211." Automatic operation continues daily without resetting. Minimum ON or OFF time, 1 hr.; maximum, 23 hr.—*International Register Co., 2620 W. Washington Blvd., Chicago 12, Ill.*



For more information circle **252** on inquiry card.

Program Controller

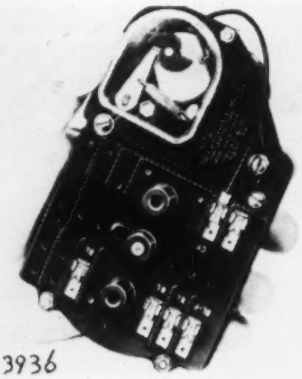
New "Automatic Programming Device" comprises a chart recorder on whose chart a program is drawn as a black line. In operation, a photocell observes black line and recorder's amplifier controls position of retransmission slide-wire, commanding electronic motor drive unit. Programs can be planned days in advance and require no supervision; also change of programs at proper preplanned time without interruption. Other features: rate of change continuously variable from zero to maximum; no hunting or oscillations. Original unit is being used to control uniform growth of germanium crystals.—*Scientific Specialties Corp., Snow & Union Sts., Boston 35, Mass.*



For more information circle **253** on inquiry card.

Appliance Timers

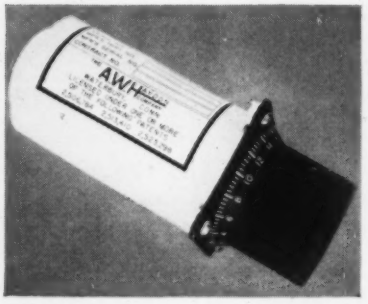
New "Constantine" timer is designed for major electrical appliances; makes maximum use of tough industrial plastics; is of extremely shallow construction; permits direct shaft connection with appliance control knob; can be supplied with operating shaft extending from either side. Entire time program is molded on both sides of a single cam.—*R. W. Cramer Co., Centerbrook, Conn.*



For more information circle **254** on inquiry card.

Automatic Timers

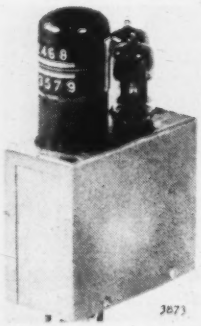
New adjustable time delay relays feature a large calibrated dial with a positive detent. Accuracy is 1 percent of setting. One model, adjustable from 2 to 30 seconds, is calibrated in two-tenth increments.—*A. W. Haydon Co., Waterbury, Conn.*



For more information circle **255** on inquiry card.

COUNTING, COMPUTING

Decade Counter

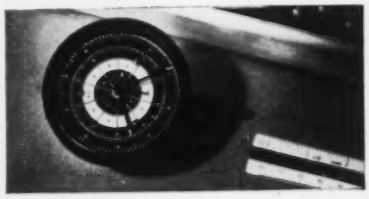


New miniaturized electronic decade counter uses "EIT" decade scaler tube; weighs 11 oz. with tubes in place; is available in four types: a 20-kc. scaler, a 40-kc. scaler, a 100-kc. scaler, and an output stage scaler operating at 10 cps. which can be used to feed a mechanical counter. The 40-kc and 100-kc types can be furnished with or without an input shaper circuit.—*Ransom Research, P. O. Box 382, San Pedro, Calif.*

For more information circle **256** on inquiry card.

Mechanical Counter

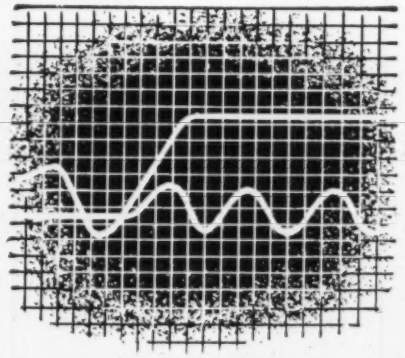
New "Rayconter Model 550 Cumulative Counter" embodies a new type of low-inertia mechanism, is conservatively rated 3,000 per minute; counts up to 999,999; registers with four pointers on four concentric scales reading from center outward. Case can be flush-panel or projected mounted; actuating lever brought out at side through a dust-sealing rubber boot. Dimensions 3.5 in. diam. by 2 in. deep. Weight 6 oz.—*Raycon Corp., 825 Willow St., Redwood City, Calif.*



For more information circle **257** on inquiry card.

Magnetic Shift Register Assemblies for Computers

New magnetic shift registers and assemblies are custom-engineered to fit specific requirements of each application. A typical assembly might consist of shift register transformers, capacitors, resistors, and chokes, as



EPIC

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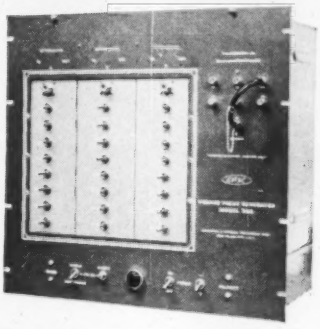

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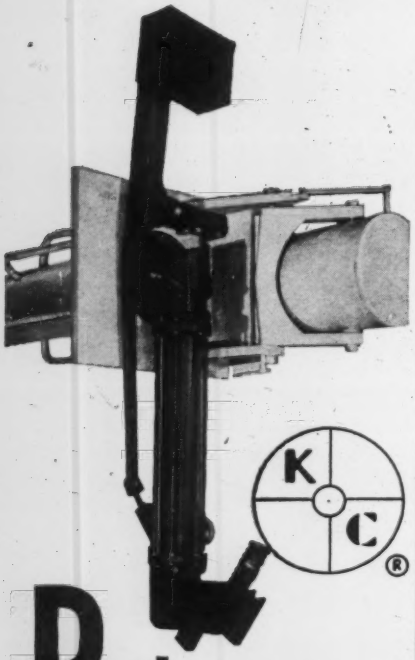

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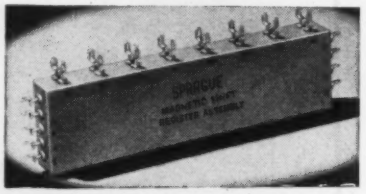
For more information circle **48** on inquiry card.

NEW INSTRUMENTS

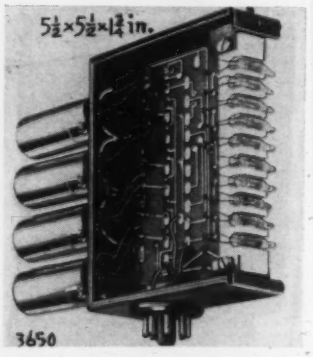


well as semiconductor diodes where required, mounted together and hermetically sealed in corrosion-resistant cases.—*Sprague Electric Co.*, 343 *Marshall St., North Adams, Mass.*

For more information circle **258** on inquiry card.

Decade Totalizer

New "TU-100P" records pulses separated by only 5 microseconds; utilizes a printed circuit which made possible faster production (and lower sell-

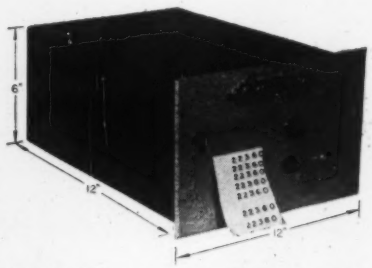


ing cost) and better stability through greater heat dissipation. No voltage regulation required; instant resetting accomplished externally.—*Computer-Measurement Div., The Detectron Corp., No. Hollywood, Calif.*

For more information circle **259** on inquiry card.

Recording Counter

New miniature version of maker's recording counter accepts pulses or contact closures at rate of 1,000 per minute, is "the fastest electromechanical recording counter on the market." Automatic reset is a standard feature but may be eliminated if totalizing is required. Printer may be actuated

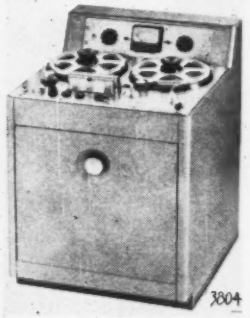


manually by push button, or automatically by signal from external timer.—*Streeter-Amet Co.*, 4101 *Ravenswood, Chicago* 13, *Ill.*

For more information circle **260** on inquiry card.

Data Tape Recorder

New dual-channel "Model 309," designed for recording telemetered information, records frequency-modulated carriers on one channel and



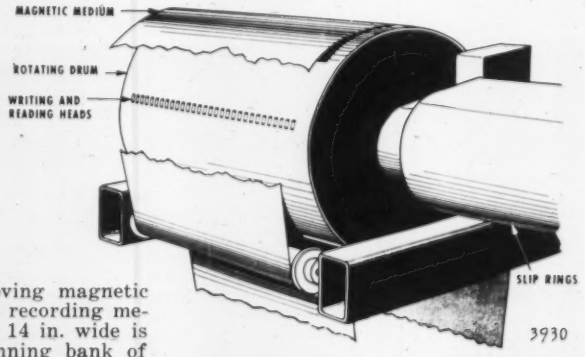
pulse-width-modulated information on lower track.—*Ampex Electric Corp.*, 934 *Charter St., Redwood City, Calif.*

For more information circle **261** on inquiry card.

Binary Code Discs

Four new types of binary code discs, for use in photoelectric, magnetic, or contact types of pickups, contain concentric zones of information in the gray code. Each zone contains alternating opaque and clear angular sectors; thin opaque rings separate adjacent zones. Number of sectors per zone increases by doubling to 2^{12}, or to 4096 in outer zone. Up to 8192 words can be read with all zones. "Type T" utilizes photoengraver's

High-capacity Memory



New "Tapedrum" magnetic memory based on an "inside-out" drum can store more than 100 million bits of information and repetitively scan 200,000 bits 20 times per second; combines principles of tape recorders and high-speed drum recorders. Basic innovation is use of moving magnetic heads and a stationary recording medium. A magnetic tape 14 in. wide is placed over a fast-spinning bank of 128 recording heads. A natural air cushion separates spinning drum of magnetic heads from tape. This virtually eliminates tape wear and need for close tolerances.—*Clevite-Brush Development Co.*, 540 *East* 105*th St., Cleveland* 8, *Ohio.*

For more information circle **262** on inquiry card.

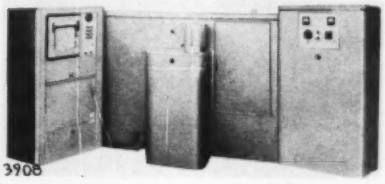
glue, with colloidal (black) silver, essentially grainless for transmission contrast; "Type R" with etched metal coating, possesses both reflectivity and transmission contrast; "Type M", with chemically deposited ferrous alloy possesses both magnetic and optical transmission contrast; and "Type C" metal bonded on glass for electrical contact use as well as in contrast of optical transmission. All four types are on polished glass and are made to precision tolerances not possible with ordinary printed-circuit techniques.—*Industrial Div., W. & L. E. Gurley, Troy, N. Y.*

For more information circle **263** on inquiry card.

LABORATORY

Spectrometer

New "No. 8950 Production Control Quantometer" is a simplified version of regular "PCQ" for those who wish to start minimum labs and expand



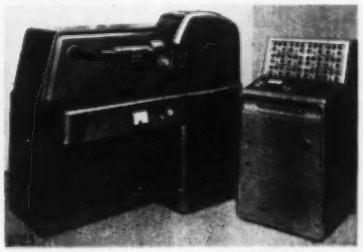
3908

later. Only 11 elements of user's choice can be analyzed as against 35 in larger instrument. Design allows gradual expansion by adding pre-built units and completely automatic controls.—*Applied Research Labs., Glendale, Calif.*

For more information circle **264** on inquiry card.

X-ray Spectrograph

New "Autrometer" automatic multi-element indexing x-ray spectrograph gives percentages of as many as twelve

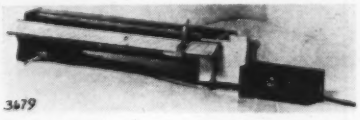


elements in a specimen in a range of over 71 elements; is radiation-proofed; provides rapid analysis of products.—*Research and Control Instruments Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.*

For more information circle **265** on inquiry card.

Melting-point Apparatus

New "Kofler Hot Benches," said to require but a few seconds to determine melting points, provides also a rapid method to observe presence and behavior of water crystal, process of decomposition, and to judge volatility. Specimen is laid on chrome-plated sur-



3479

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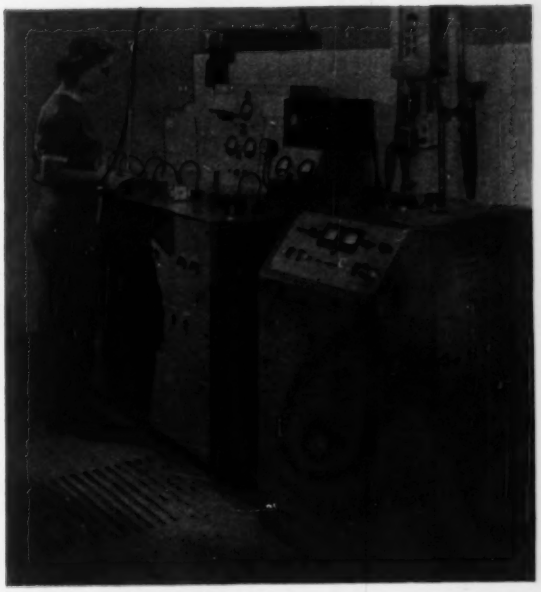
Low pressure . . . humidity . . . dust . . . fungus . . . salt corrosion . . . explosion. All or any one of these can cause failure of aircraft electronic components, so protection against them must be near absolute.

Leach Relay Company of Los Angeles achieves positive protection of their aircraft relays and *Hi-Seal* packaged circuitry by pumping out and dehydrating each unit, filling it with an inert gas and hermetically sealing it. Heart of the entire procedure is a Consolidated Leak Detector. Working at high speed, locating leaks undetectable by any other method, the CEC Leak Detector assures that units will pass the stringent government sealing specifications . . .

. . . helps planes and missiles deliver the "punch" designed into them.

Consolidated leak detection assures success



Now, two CEC leak detectors

The standard Type 24-101A detects one part of helium in 200,000 parts of air . . . measures leak rates to 10^{-9} std cc/sec. The new ultra-sensitive Type 24-110 detects one part of helium in *2,000,000 parts of air!* It is valuable, for example, in atomic-reactor equipment and in the production of "reliable-type" electron tubes. Send for Bulletin CEC 1801D-X2.

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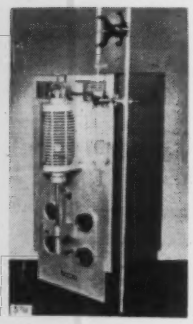
For more information circle **49** on inquiry card.

face of pre-heated Hot Bench. Within a few seconds, a sharp dividing line appears between solid and liquid parts of substance. A runner is moved until point rests on dividing line, and temperature is read. Accuracy, one C. degree.—*Wm. J. Hacker & Co., Inc., 82 Beaver St., New York 5, N. Y.*

For more information circle **266** on inquiry card.

Combustion Analysis Apparatus



New "LI-500P H-F Combustion Unit" makes possible fast combustion of heavy and light hydrocarbons. All samples covered by ASTM Bomb or Lamp Method can be completely combusted. Complete analysis takes 15 to 20 min. from initial weighing to final computation. Once weighed sample is placed in induction field, operator devotes his entire attention to titrating (iodometric method). Furnace temperature can exceed 3000 F.—*Lindberg Laboratory Div., 2450 W. Hubbard St., Chicago 12, Ill.*

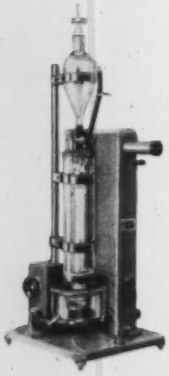
For more information circle **267** on inquiry card.

Warburg Apparatus

New circular rotatable Warburg apparatus for precise micro-gas analysis is 31-in. high, 20-in. diam.; has an exclusive intramolecular lagless heating system said to assure extremely uniform temperature. Standard "UV" unit, and "UVL" designed for photochemical work, are both available. Among features: six reproducible shaking speeds and three amplitudes; temperature constancy 0.01 C. or better; and new "Double Capillary (single rod) Manometer."—*Bronwill Scientific, Inc., 131 Gould St., Rochester, N. Y.*

For more information circle **268** on inquiry card.

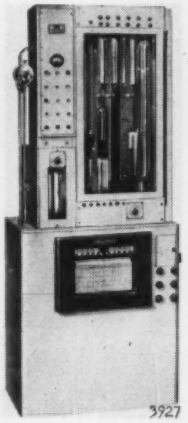
Particle-size Apparatus



New particle size apparatus was designed for sub-sieve range (75 to 5 microns). If top size is not greater than about 20 microns, lower limit can ordinarily be extended to about 2 microns. Apparatus comprises a sedimentation system, a receiving tank, and a direct-reading torsion balance. Powder is uniformly dispersed in a suitable liquid, and particles are allowed to settle on pan of torsion balance. Time required to estimate size distribution of any powder is little longer than time of sedimentation.—*Arthur S. LaPine & Co. 6001 S. Knox Ave., Chicago 29, Ill.*

For more information circle **269** on inquiry card.

Hydrocarbon Analyzer

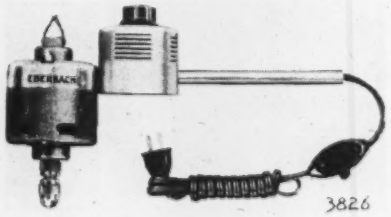


New "Fracton" performs fast accurate analyses of light hydrocarbon gases by adsorption fractionation, "two to three times faster than any previous method," with all analytical procedures easy to standardize. Trace gases are easily identified and measured, fractions may be collected and preponderate light gases may be taken rapidly overhead. Instrument comes ready for use; has no fragile connections, no glass stopcocks, no rubber connections in flow system; needs no refrigerants.—*Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Penna.*

For more information circle **270** on inquiry card.

Variable-speed Stirrer

New variable-speed model of maker's "Hollow Spindle Lab-Stir"

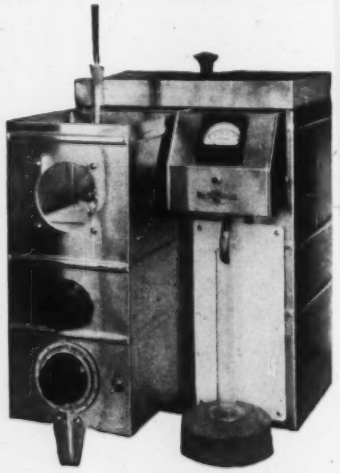


provides continuous light-duty stirring from 100 to 1550 rpm. under load. Up to 5 gal. of aqueous solutions can be mixed vigorously.—*Eberbach Corp., Ann Arbor, Mich.*

For more information circle **271** on inquiry card.

Distillation Wattmeter

New "Visi-Watt" accessory for "Front-View" distillation unit enables many distillations of petroleum prod-

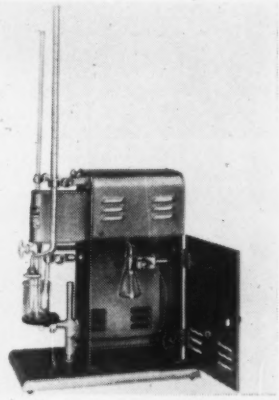


ucts to be run more accurately and easily because indication of exact power consumed by heater permits compensation for line fluctuations.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **272** on inquiry card.

Titration Cell

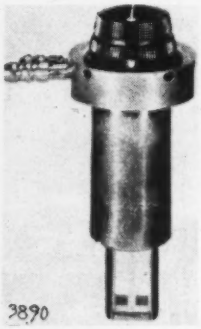
New "Precision-Shell Amperometric Titration Cell," adjunct to a polarographic instrument, permits rapid de-



termination of low concentrations of various cations and anions without involving either indicator corrections or interference from colored solutions.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **273** on inquiry card.

Colorimeter Cell

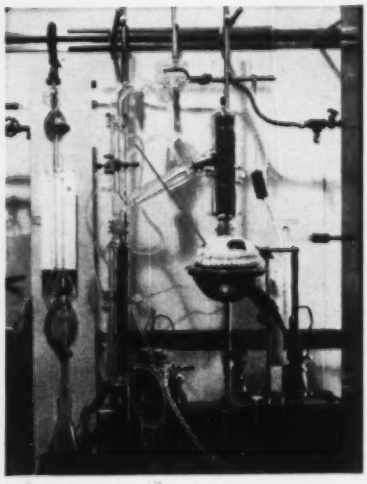


New "Roto-Cell" is a liquid-cooled double cell carrier for use with new B&L "Spectronic 20" colorimeter to make it suitable for rapid spectrophotometric scanning at controlled temperatures. It provides for instantaneous interchange, within colorimeter, of a 1-ml. sample with blank or standard into light path, facilitating preparation of spectral curves.—*Arthur H. Thomas Co., 230 S. 7th St., Philadelphia 5, Pa.*

For more information circle **274** on inquiry card.

Vacuum-still Column

New vacuum-jacketed distillation column was developed to coordinate with a standardization program relating to use of ASTM-type distillation



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®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

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- No internal wearing parts.
- No valves, pistons, or vanes.
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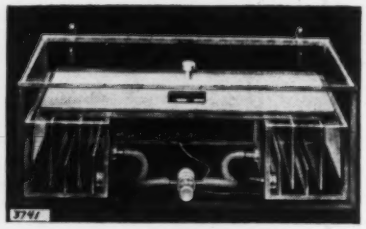
NEW INSTRUMENTS

for characterization of lubricating oils and reduced crudes. Test operations have been conducted at temperatures up to 750 F. and pressures down to 1 mm Hg. No breakage; and experience shows that distillation and warm-up time are not critical.—*Glass Engineering Lab., 555 O'Neill Ave., Belmont, Calif.*

For more information circle **275** on inquiry card.

Paper Electrophoresis Apparatus

New "Model 1400" is a research model paper electrophoresis apparatus. Paper strips can be used in open

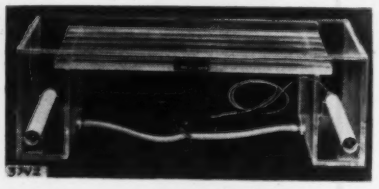


suspension or between glass plates, since enclosing plastic cabinet serves as a vapor saturation chamber. Starch tray technique can also be employed. —*Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.*

For more information circle **276** on inquiry card.

Paper Electrophoresis Apparatus

New "Model 1405" electrophoresis unit, for routine work in labs where

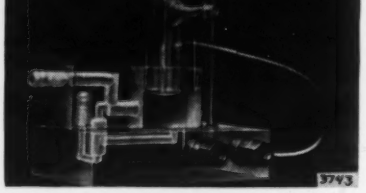


refinements of a research instrument are not needed, is simple in design but incorporates functional advantage of enclosed vapor saturation chamber.—*Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.*

For more information circle **277** on inquiry card.

Electrodesalter

New "Model 1236" electrodesalter apparatus for use in chromatography, etc., is essentially an electrodialysis

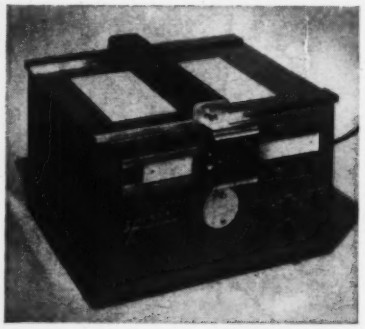


unit which may be operated by a suitable d-c. power supply.—*Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.*

For more information circle **278** on inquiry card.

Recording Densitometer

New "Analytrol" autographic totalizing densitometer produces a component distribution curve and an ac-

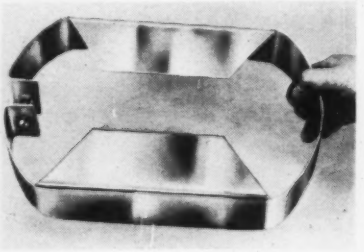


companying saw-tooth totalizing curve simultaneously, as a variable-density strip (such as a paper electrophoresis pattern) is automatically drawn through scanning mechanism. Alternatively, totalizing curve can be autographed from any existing distribution curve.—*Specialized Instruments Corp., 688 O'Neill Ave., Belmont, Calif.*

For more information circle **279** on inquiry card.

Chromatography Aid

New "Chromatoplat" is a stainless steel platform designed for use with 12-in. diam. chambers for ascending

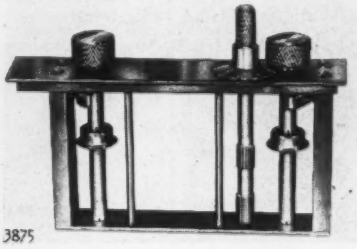


or descending chromatography. It is said that "in many instances one chamber will do where two have been used."—*The Nalge Co., Inc., 625 S. Goodman St., Rochester, 20, N. Y.*

For more information circle **280** on inquiry card.

Paper-strip Scanning Aid

New scanning device for obtaining precise photometric or radioactivity readings of paper strips in electrophoresis and chromatography fits into

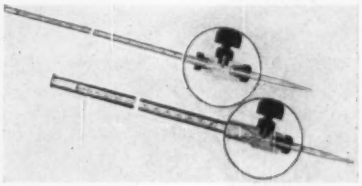


cell chamber of Beckman DU (with an adapter into Model B) and into maker's sample holder for standard G-M tubes.—*Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.*

For more information circle **281** on inquiry card.

Needle Valve Burets

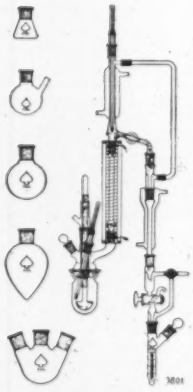
New needle valve burets in all sizes from macro to micro make it possible to control liquids for fine micro meas-



urements; eliminate stopcock grease contamination: liquid comes in contact with only glass and Teflon. Tubes calibrated to NBS tolerances. Fused-in ceramic scale insures permanent linearity.—*The Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

For more information circle **282** on inquiry card.

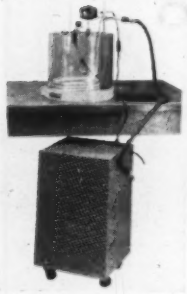
Lab Glassware



New line of maker's "Mini-Lab" glassware, for both micro and conventional research work, features one standard-size joint, assuring interchangeability regardless of when purchased. "10106 Distillation Assembly" (illustrated) available in 50-ml. and 100-ml. flask capacities, is among eleven available basic assemblies.—*Ace Glass Inc., Vineland, N. J.*

For more information circle **283** on inquiry card.

Lab Bath Cooler



New "Lanco Portable Water Bath Cooler" can cool a 5-gal. water bath from room temperature to 32 F. in less than 2 hours; controls temperature in a range from 0 F. to ambient by thermoregulator plugged into convenient outlet in top of cabinet: built-in relay takes any thermoregulator of user's choice. When not in use, unit can be rolled under bench or into a closet.—*Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.*

For more information circle **284** on inquiry card.

Stark Modulator

New Stark-effect modulator, first unit in maker's new line of electronic equipment for microwave spectroscopy, provides a referenced high voltage and a variable-frequency square wave to be applied to waveguide electrode containing gas under test. Output level is continuously variable from 10 to 1000 volts pk to ground over frequency range of 50 to 30,000 cps. and is moni-

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miniature but mighty!
You can depend on
DALOHM Ω
TYPE RSE RUGGEDIZED
MINIATURE
POWER RESISTORS
Designed for trouble-free performance under the most exacting conditions of shock and vibration.
Completely welded from terminal to terminal, sealed in silicone and housed in metal tubing. (Suggested mounting clip: Atlas E-E Corp.) Impervious to moisture, salt ions, vapor and gases.
Three wattage ranges: RSE-2, 2 watts; RSE-5, 5 watts; RSE-10, 10 watts.
• Temperature coefficient 0.00002/Deg. C
• Ranges from 0.1 ohm to 55,000 ohms depending on type
• Tolerances 0.05%, 0.1%, 0.25%, 0.5%, 1%, 3%, 5%
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For more information circle **51** on inquiry card.

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For more information circle **52** on inquiry card.

tored. Either sine wave or pulse input may be utilized in driving modulator. Unit is completely self-contained and may be rack-mounted if desired.—*Polarad Electronics Corp.*, 100 *Metropolitan Ave., Brooklyn* 11, *N. Y.*

For more information circle **285** on inquiry card.

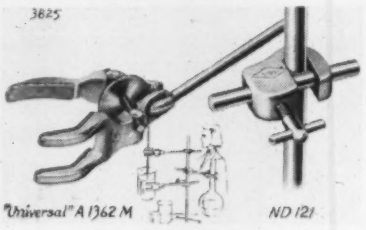
Lab Marking Tool

New "Tech-Pen" ball-point pen writes with opaque ink on virtually any surface—glass, metal, plastic, etc. Its permanent ink resists washing, rubbing, acids, alkalies, alcohol, and temperatures up to 500 C. (with one color, red, up to 1000 C.). Yet markings are easily removed, when desired, with common solvents.—*Palo Laboratory Supplies, Inc.*, 81 *Reade St., New York* 17, *N. Y.*

For more information circle **286** on inquiry card.

Clamp and Clamp Holder

New "Nivoc Universal" clamp, with easily operated thumb-wheel, features a gripping range of 0 to 4 in.; double-



V jaws facing curved clamping jaw give secure five-point contact. ★New "Nivoc" clamp holder permits simultaneous horizontal and vertical adjustment.—*Ealing Corp., Box* 51, *Stuyvesant Sta., New York* 9, *N. Y.*

For more information circle **287** on inquiry card.

Portable Comparator

New portable length and width comparator can be used to check measurements to 0.0001 in. on work in prog-

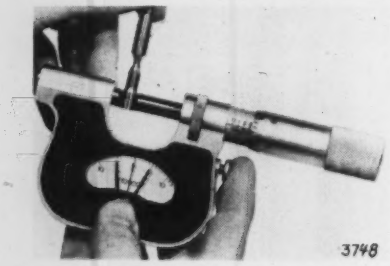
ress or on completed jobs; is readily adjustable to inspect one or several of measurements on a single part. Two standard sizes: 0-6 in. and 0-12 in.; larger sizes special.—*Jerpbak-Bayless Co., Solon, Ohio.*

For more information circle **292** on inquiry card.

DIMENSIONAL GAGING and INSPECTION

Indicating Micrometer

New "Master Compar" providing "visible feel" has 1-in. range, reads in 0.0001 in. Indicating mechanism controls measuring pressure, eliminat-

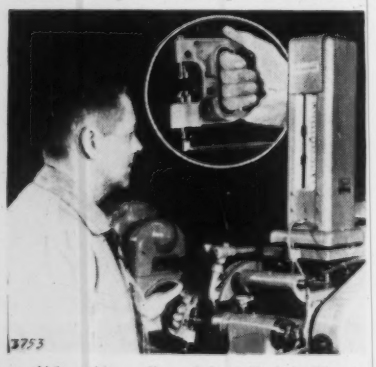


ing uncertainties due to differences in "feel" of individuals. Instrument serves also as a full set of GO and NO GO gages of 1-in. range. Larger sizes (up to 4 in.) furnished with removable indicator.—*George Scherr Co., Inc.*, 200 *Lafayette St., New York* 12, *N. Y.*

For more information circle **238** on inquiry card.

Pneumatic Gage

New "Plunjet Adjustable Airsnap Gage" connected to a flow type "Precisionaire" provides up to ten times

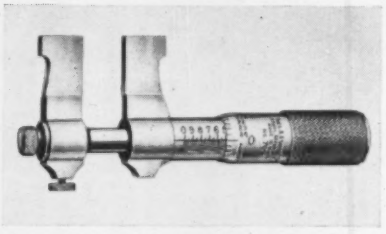


amplification offered by dial indicator snap gages. Twelve models available, up to 12 in. in 1-in. increments. "Plunjet" gaging cartridge is interchangeable.—*The Sheffield Corp., Dayton* 1, *Ohio.*

For more information circle **289** on inquiry card.

Inside Micrometer

New "No. 700 Inside Micrometer Caliper" combines convenience and quick-reading features of a microm-

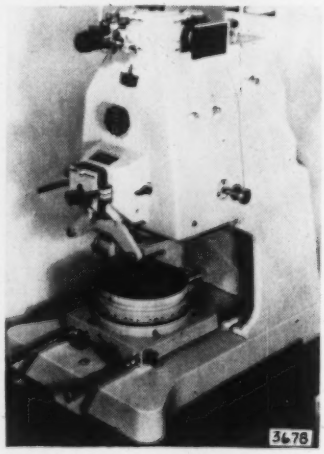


eter with vernier caliper-style jaws. Range 1.000 in. to 2.000 in. by thousandths.—*The L. S. Starrett Co., Athol, Mass.*

For more information circle **290** on inquiry card.

Interferometer

New interferometer features optical arrangement which reproduces interference images completely free from reflection and free from distortion owing to specially corrected lenses in il-

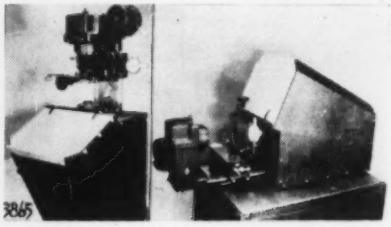


lumination and observation paths of ray. Surfaces up to 140 mm. can be tested for planeness; comparison of gage blocks to 0.05 micron accuracy; etc.—*Wm. J. Hacker & Co., Inc.*, 82 *Beaver St., New York* 5, *N. Y.*

For more information circle **291** on inquiry card.

Optical Comparator

New "Economy Size Duplex Type Universal Optical Comparator" has all of basic features required for tool-



room or production line inspection; can be used on a shop bench or stand in either vertical or horizontal position. Slide type insertion screen frame accommodates standard 8½ x 11-in. overlay charts.—*Portman Instrument Company, Inc., Town Dock Road, New Rochelle, N. Y.*

For more information circle **293** on inquiry card.

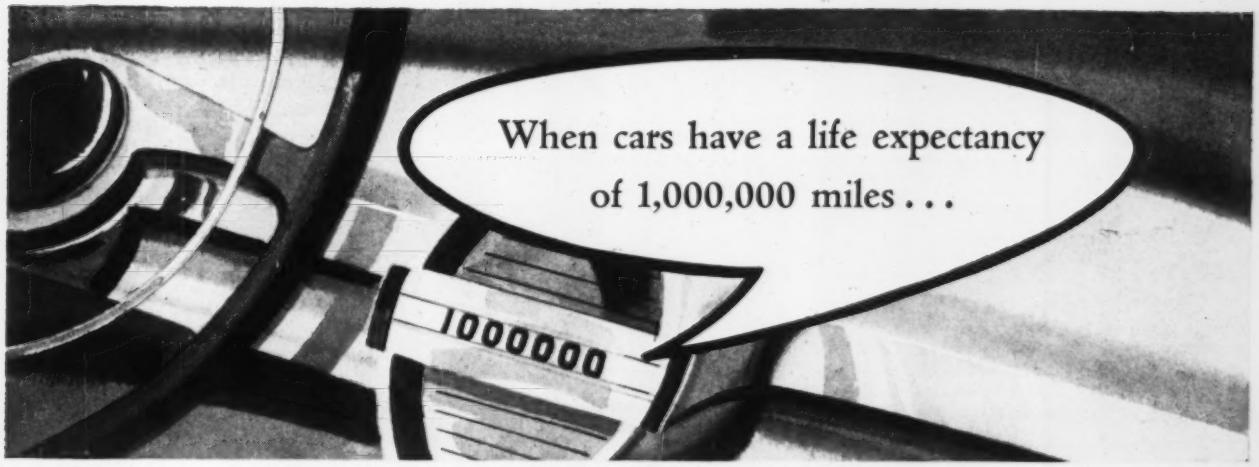
Production Bench Gage

New "Model BG103" is for rapid dimensional checking of parts. Hand lever quickly lowers hardened steel table to permit entrance of workpiece without raising indicator plunger. For handling parts requiring use of both hands, gage can be fitted with a foot pedal. Dial indicator regularly supplied has 0.125-in. range in 0.0004-in. graduations. Others available. Vertical capacity 1⅜ in.; table travel 0.3 in.—*Chicago Dial Indicator Co.*, 180 *N. Wacker Drive, Chicago, Ill.*

For more information circle **294** on inquiry card.

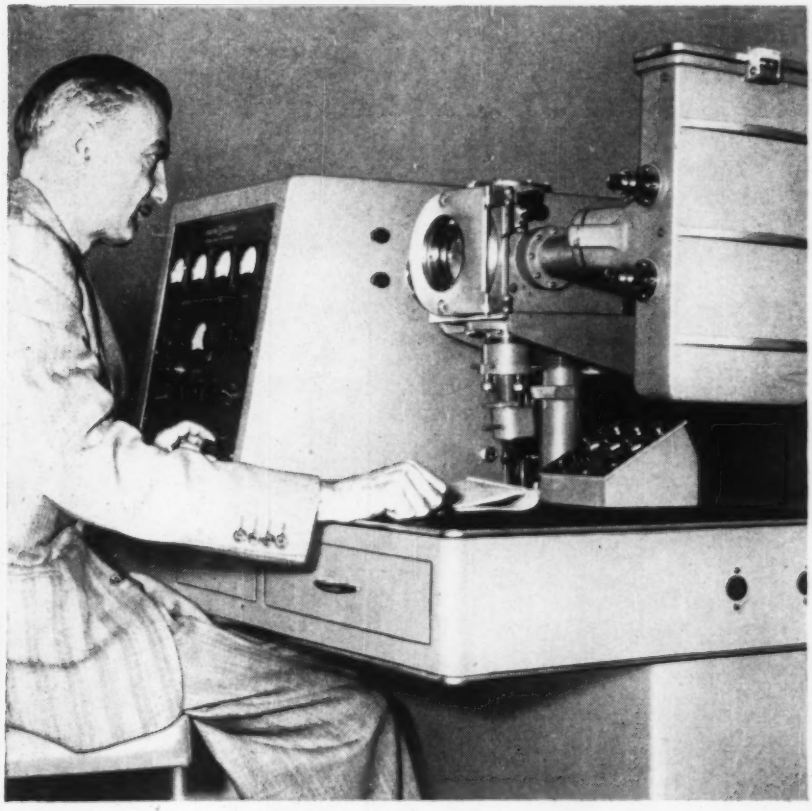
Portable X-Ray Unit

New "OX-175" portable industrial x-ray unit capable of producing a 360 degree radiation sweep permits products to be set up in a circle around its tube head to reduce radiographic operation time in some industries by as much as 97 percent. It can be placed inside a pipe or pressure vessel and used to take "inside out" x-ray views;



Electron diffraction can help solve problems in chemistry, physics and metallurgy. By diffracting a beam of electrons from a surface, you can identify the crystal structure of that surface. By using this technic for research into the structures of lubricants and metals, it's quite likely that your car of the future will have fantastic longevity.

chances are that research with electron diffraction will have helped make this come true



• *The General Electric electron diffraction instrument* is versatile and easy to operate. The unit consists of vacuum system, electron gun, power supply and complete camera assembly — all the components required to produce both reflection and transmission photographs from a wide variety of samples.

Electron beam energy is continuously adjustable from 25 to 50 kv, for precise selection of operating voltage. Electron beam is focused on the photographic plate by a magnetic coil which provides the best focused beam for each experiment. You can examine specimens up to 4 inches in diameter. Camera plate magazine holds up to 5 plates, so you can take as many as 5 exposures without breaking vacuum.

Get further information from the G-E x-ray representative in your locale . . . or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. BL-24.

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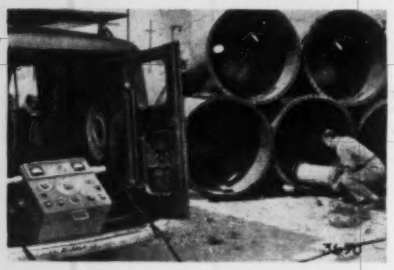
For more information circle 53 on inquiry card.



can be operated at x-ray tube voltages from 45,000 to 175,000; features operator convenience and automatic safeguards.—*General Electric Co., X-Ray Dept., 4855 Electric Ave., Milwaukee 1, Wis.*

For more information circle **295** on inquiry card.

Gage Block Set

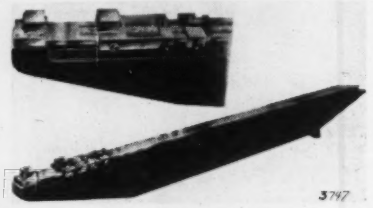
New heavy-duty 84-block gage set, accurate to 4 microinches, contains fixtures which will assemble blocks for use as dividers, scribers, and height

or snap gages, in addition to their normal gaging function.—*Webber Gage Co., 12899 Triskett Road, Cleveland 11, Ohio.*

For more information circle **296** on inquiry card.

Measuring Machine

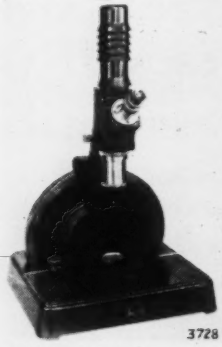
New Length Measuring Machine, for external as well as internal measurements, reads by means of steel



scale and extra-large vernier to 0.001 in. and 0.02 mm.; can be used as "Master" or "Check" for large micrometers, gages, etc. Two models: 80-in. weighing 300 lbs., and a 120-in. weighing 400 lbs.—*George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.*

For more information circle **297** on inquiry card.

Angle Comparator

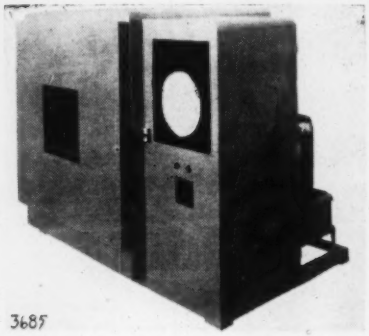


New Angle Comparator for comparing parallelism between two surfaces, squareness and angles, enables rapid production-basis inspection of finished parts, many of which cannot be inspected by other methods. It operates entirely on optical principles: no pressure on piece being inspected, no dependence on operator "feel."—*The Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **298** on inquiry card.

Fungus-humidity Chambers

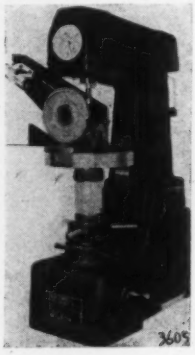
New "Series FH," specially designed for small manufacturers, feature tem-



perature recorder, watertight stainless steel liner and specimen shelves, sealed viewing window and distilled water feed. Optional extras include program control.—*Hieatt Engineering Co., P.O. Box 349, Burbank, Calif.*

For more information circle **301** on inquiry card.

Gear Hardness Tester



New "Universal Quick-change Pitch Line Gear Testing Fixture," designed for use on a Rockwell Superficial Hardness Tester with gooseneck type Brale, will accommodate gears of various sizes in lab or production operation. Hardness test cycle can be completed in seconds. A safety device prevents injury to Brale should elevating screw be lowered too far.—*American Chain & Cable Co. Inc., Bridgeport 2, Conn.*

For more information circle **302** on inquiry card.

MECHANICAL TESTING

Refrigerated Rooms

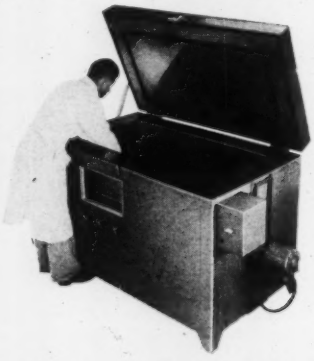
New type of refrigerated constant-temperature rooms feature rapid yet close control of conditioning medium,

permitting temperature control within 1 C. deg.—*Electric Hotpack Co., Inc., 5065 Cottman Ave., Philadelphia 35, Pa.*

For more information circle **299** on inquiry card.

Thermal Test Chamber

New "Model D-102 High-and-Low Temperature Test Chamber" operates over a range of –100 F. to 300 F. with



2 F. accuracy. An inner working volume of 12 cu. ft. permits installation of large assemblies, and a group of 3-in. access holes simplifies attachment of instrumentation and power leads, fuel and flow lines or vibration actuators. Thus, tests can be carried out during operation.—*Mantec, Inc., 130 Maryland St., El Segundo, Calif.*

For more information circle **300** on inquiry card.

Brinell Hardness Tester

New "Color-glance Brinell Hardness Testing Machine" features three signal lights: yellow indicates "too hard," green "within range" and red "too soft." Limits are adjustable. Otherwise, new machine is similar to company's "Models KDR-6" and "KDR-10." For completely automatic operation, circuits which operate lights can be used to actuate solenoids, etc., to classify parts.—*Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 38, Mich.*

For more information circle **303** on inquiry card.

Automatized Molecular Weight Apparatus

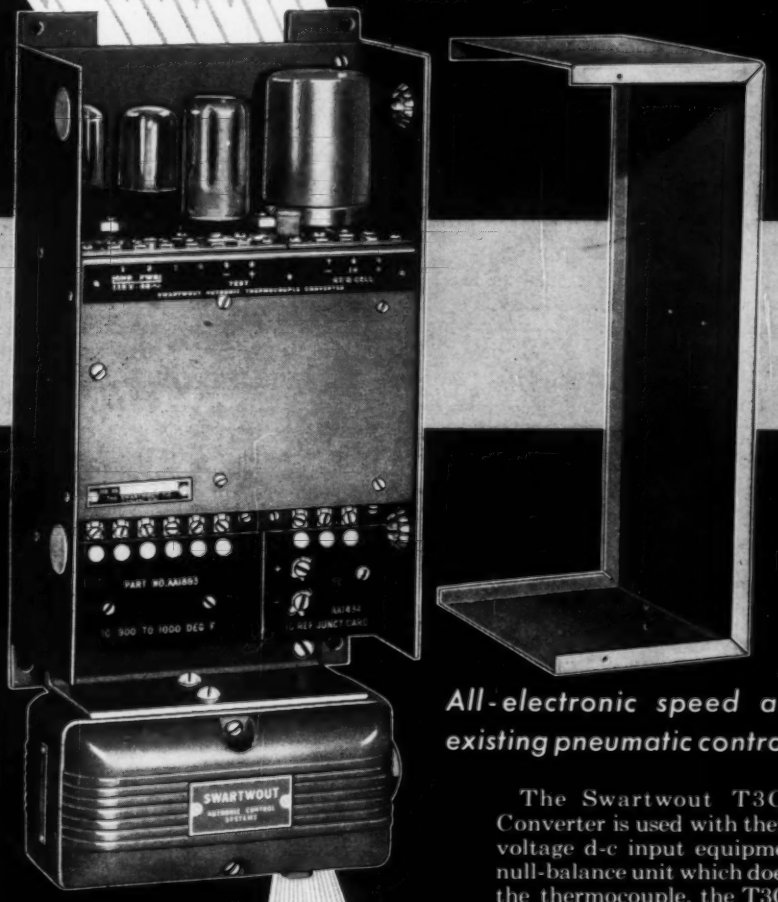
New "Kellogg ZST" tester determines molecular weight of thermoplastic high polymers within a few minutes after a part has been produced, by measuring time required to

New Product Announcement

D-C SIGNAL

Swartwout

THERMOCOUPLE-AIR CONVERTER



Swartwout T3C Thermocouple-Air Converter uses no batteries, slide wires or motors. Also furnished in explosion-proof design so that final conversion to pneumatic output can be in hazardous area remote from amplifier.

All-electronic speed and accuracy with existing pneumatic controllers and recorders

The Swartwout T3C Thermocouple-Air Converter is used with thermocouples or other low voltage d-c input equipment. A high-impedance, null-balance unit which does not draw current from the thermocouple, the T3C converts d-c millivolt input signals to a 3-15 psig output air signal in an accurate linear relationship between electrical input and air output.

This means your existing air-operated components can benefit from the inherent infinite sensitivity and much higher rate-response control settings of the Autronic System of all-electronic process control.

A wide spectrum of standard temperature ranges from a low of −50 C to a maximum of 3000 F is available. Range is quickly and easily altered by interchangeable range cards for fixed temperature or voltage input ranges, or by continuously adjustable range cards.

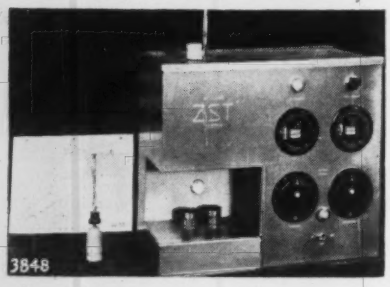
AIR OUTPUT

Swartwout

Autronic CONTROL SYSTEM

THE SWARTWOUT COMPANY • 18511 EUCLID AVENUE • CLEVELAND 12, OHIO

For more information circle **54** on inquiry card.

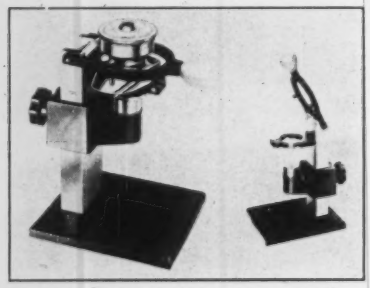


break a standard notched strip of heated polymer weighted with a small static load. In operation, notched samples are inserted in furnace; timers and pilot lights start automatically; when samples break, dropping weights fall into cups below respective furnace openings and cut off pilot lights and recorders. Developed by The M. W. Kellogg Co., commercially available from *F. J. Mullowney Co.*, 160 *Passaic St., Trenton, N. J.*

For more information circle **304** on inquiry card.

Hardness-tester Adapter

New "Bench Adapter" for maker's portable metal hardness testers minimize test time and prevent operator

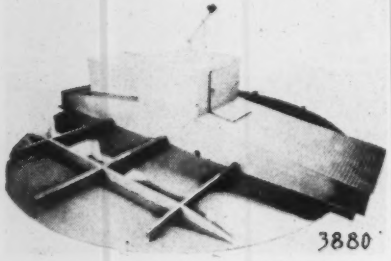


fatigue. Standard anvil accepts most workpieces; custom anvils to order for special sizes.—*Newage International, Inc.*, 235 *E. 42nd St., New York* 17, *N. Y.*

For more information circle **305** on inquiry card.

Rotary Accelerator

New "Model T-16-A" rotary accelerator, designed to apply approx. 100 *G* to test objects, controls test conditions on components weighing up to 500 lb. and as large as 5 cu. ft. Accurate transmission of signal voltages



is obtained by use of 60 coin-silver-faced slip rings. Rotating 16-ft. test arm, installed in an 18-ft. diam. pit supplied by user, can be designed to fit individual applications. Option: optical system for observing test objects as if they were stationary.—*Schaevitz Machine Works, Camden* 1, *N. J.*

For more information circle **306** on inquiry card.

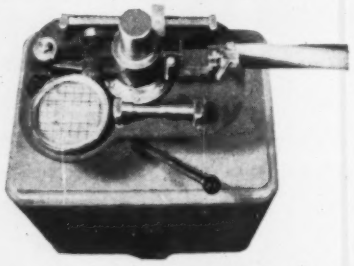
Torque Gage

New torque tool measures from 0 to 170 gram-inches; is said to be "ideal for delicate work on instruments." Length 7 in.; easy-to-read dial measures either left or right torque; interchangeable screwdriver or wrench bits.—*Apco Mossberg Co.* 203 *Lamb St., Attleboro, Mass.*

For more information circle **307** on inquiry card.

Blade-balance Tester

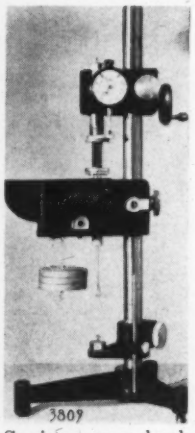
New "Model 9730 Moment Comparator" determines deviations of moment weights of individual blades for jet



engine rotors, on a radius identical with that of final disc assembly (said to be "the only radius measurement that will give accurate classification"). Simultaneously, it measures tangential deviations from specified center of gravity.—*Micro-Poise Engineering and Sales Co.*, 14851 *Grand River Ave., Detroit* 27, *Mich.*

For more information circle **308** on inquiry card.

Spring Tester



New improved "Baldwin-Hunter" spring tester with double its former capacity has new worm-gear-drive head which provides for obtaining load-deflection curves readily for both compression springs, as shown, or for extension springs, by placing adjustable head below weighing head on 27-in. high stainless steel column. Springs may be loaded up to 10 lbs. —*Baldwin-Lima-Hamilton Corp., Philadelphia* 42, *Pa.*

For more information circle **309** on inquiry card.

X-ray Tube

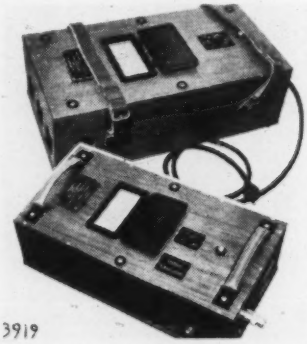
New "FE 150" fine-focus field-emission type X-ray tube, specially suited for high-speed radiography, features fine focal spot size at anode potential 50kv.-150kv. at 0.2 usec.—*Resitron Laboratories, Inc.*, 2908 *Nebraska Ave., Santa Monica, Calif.*

For more information circle **310** on inquiry card.

ELECTRICAL TESTING

Insulation Testers

Two new models of "Megger" insulation testers are available in rectifier-operated units: one having a range up to 100,000 megohms at 5000 v.dc.



with 1000-v. and 2500-v. intermediate ranges, and one having a range up to 200,000 megohms at 10,000 v. with no intermediate voltage ranges.—*James G. Biddle Co.*, 1316 *Arch St., Philadelphia* 7, *Pa.*

For more information circle **311** on inquiry card.

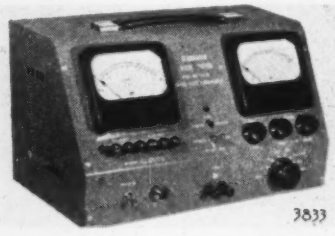
Insulation Tester

New "Hipot" tester and fault indicator is for continuous production testing of insulating materials, tapes, insulated wire, coated foils etc. Dual power supplies, one up to 20,000 v., with dual electrodes, dual detectors, magnetic recorders. In addition to counting faults, dual provision for operating solenoids, etc. Extremely high detector sensitivity (10 microamps) permits non-destructive testing and use of simple high-resistance electrodes.—*Peschel Electronics, Inc.*, 13 *Garden St., New Rochelle, N. Y.*

For more information circle **312** on inquiry card.

Germanium Diode Tester

New "Model 110A" provides five preset tests and additional variable test; push button current scales; vari-

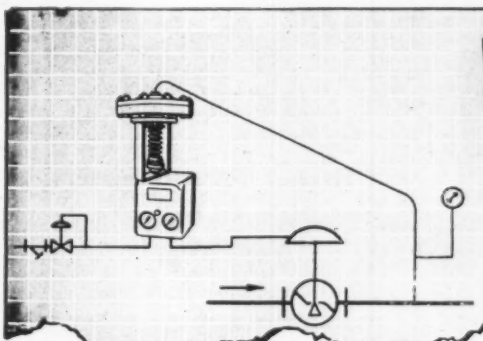


able voltages available on all scales.—*Empire State Labs., Inc.*, 2608 *Merrick Rd, Bellmore, N. Y.*

For more information circle **313** on inquiry card.

Resistance Comparator

New Resistance Comparator plugs directly into a 115- or 230-volt lighting circuit; requires no adjustments; is constructed for constant use by unskilled workmen. Indication with zero oscillation: no hunting. Readable to 0.01 percent accuracy interpreted into



WHEN TO USE A CONTROLLER

PRESSURE, TEMPERATURE AND LIQUID LEVEL CONTROLLERS

Leslie Controllers consist of a single or double seated diaphragm control valve operated by a Control Pilot. The latter is an air, water or oil actuated device that produces a variable loading pressure to the valve diaphragm in response to a pressure, temperature or level change in the controlled medium. Controllers are used for any one or any combination of the following conditions:

★ When an exactly controlled level, pressure or temperature is required.

★ When power is needed to assure automatic valve opening after prolonged, tight shut-off.

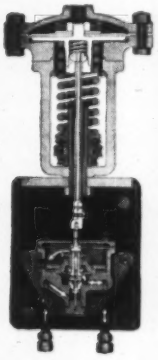
★ When power is needed to operate single-seated valves under high pressure drop.

★ When the available fluid pressure differential doesn't supply enough power for self-operation.

★ When extreme pressure reductions are necessary (i.e. 600 reduced to 10 psi, 900 to 2 psi, 2150 to 5 psi); all can be handled in one step.

★ When fluid contamination requires the simplest type regulating valve for dependable operation.

★ When operation from either a nearby or remote control station is desired.

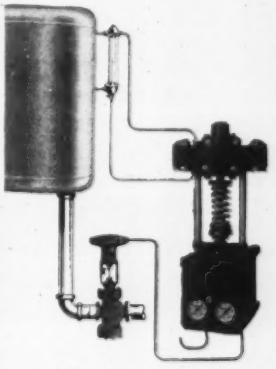


Control Pilot
Type PD

LESLIE
CONTROL PILOTS

Simple mechanical device employing constant supply of clean air, gas, water or light oil at 20-22 psi to produce a variable output or loading pressure of 0-20 psi in response to a level, pressure or temperature change applied to operate a control valve or power cylinder controlling fluid flow.

SEND FOR BULLETIN 5303



Floatless Level Control
Type UA-1

LESLIE
FLOATLESS LEVEL CONTROL

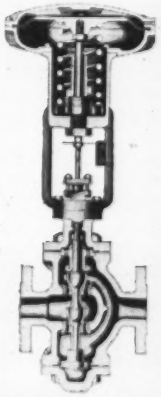
Provides accurate control of liquid level (plus or minus 1" water column). Eliminates problems caused by troublesome linkages, torque tubes, floats and stuffing boxes. Simple design provides steady, positive, precise control even under difficult conditions. Consists of Level Control Pilot and diaphragm control valve.

SEND FOR BULLETINS
5303, 5304, 5305

LESLIE
DIAPHRAGM CONTROL VALVES
(Double Seated)

Flow-line contoured body for high capacity, low pressure drop. Standard ISA face to face dimension in cast iron, cast bronze and cast alloy steels. Renewable, self-aligning guides. ½-10". To primary service rating of 600 psi—950° F. flanged, ring joint and welding ends.

SEND FOR BULLETIN 5305

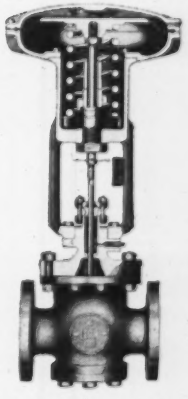


Diaphragm Control Valve
Double Seated Class DV

LESLIE
DIAPHRAGM CONTROL VALVES
(Single Seated)

Control flow of steam, liquid, air or gas. Tight shut-off. Operated automatically by air, water or oil pressure supplied from a Control Pilot or from a loading device such as LESLIE Air Loading panel. Available in unbalanced or fully balanced types, ½-10" in cast bronze, cast iron and cast alloy steels. Primary service ratings to 2500 psi, 1000° F.

SEND FOR BULLETIN 5304



Diaphragm Control Valve
Single Seated Class DL-1

5198

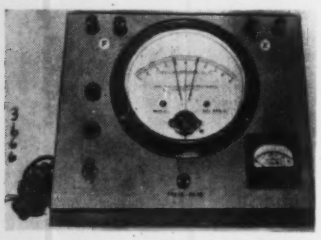
LESLIE CONTROLLERS

SINCE 1900

"STILL FAR AHEAD IN QUALITY AND PERFORMANCE"

LESLIE CO., 253 GRANT AVENUE • LYNDHURST, NEW JERSEY

For more information circle **55** on inquiry card.

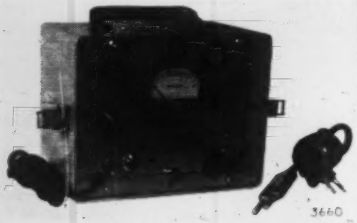


percentage of difference in resistors compared. Available in three ranges: 10-1000 ohms, 1-100 ohms and 1-50 ohms.—*R. L. Fearn, 375 S. Main St., Homer City, Penna.*

For more information circle **314** on inquiry card.

Insulation Tester

New "Model-22 Electronic Megometer" is a calibrated high-resistance

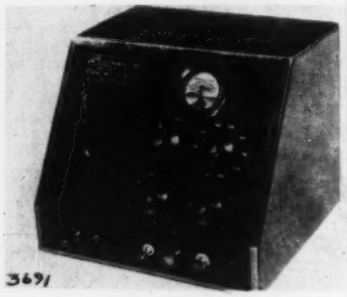


ohmmeter with a 500-v.dc. constant voltage source. Indicating microammeter is protected against shorts but still provides calibrated indication of insulation or other resistance as high as 200 megohms.—*Electronic Engineering & Service Co., Inc., 104 West Jefferson St., Falls Church, Va.*

For more information circle **315** on inquiry card.

Turns Measuring Set

New Turns Measuring Set virtually eliminates rejects due to wrong count



in coil winding; requires no special knowledge. Range 1 to 1999 turns; minimum coil diameter 0.35 in.; sensitivity 4 turns off scale.—*Infra Electronic Corp., 553 Eagle Rock Ave., Roseland, N. J.*

For more information circle **316** on inquiry card.

ELECTRICAL INSTRUMENTS

Expanded-scale Voltmeter

New "Expanded Scale Panel Voltmeter" provides a-c. voltage readings accurate to 0.5 percent over frequency range of 50 to 2000 cps. Use of a thermal bridge permits normal voltage to be as low as 6.25 v. with a span of plus and minus 0.25 v. or as high as 230 v. with a span of plus and minus 30 v.—*Arga Div., Beckman Instruments, Inc., South Pasadena, Calif.*

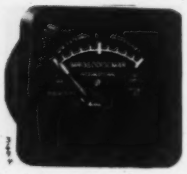
For more information circle **317** on inquiry card.

Wide-range Voltmeters

New "Electronic DC Millivolt Meters" are said to cover voltage range of 100 microvolts to 1 kv. at 6 megohms input impedance on low ranges and 60 megohms on all ranges above 1 v. full-scale. They contain an accurately tuned 120-cps. d-c. modulator driven from highly stable 60-cps. *RC*-tuned oscillator; are available also as highly stable d-c. amplifiers with gain of 1500 and d-c. drift of less than 50 uv.; operate at power supply frequencies of 40 to 500 cps.—*Millivac Instrument Corp., 444 Second St., Schenectady 6, N. Y.*

For more information circle **318** on inquiry card.

Miniature Electrical Indicating Instruments



New "Model 163" 1½-in. ruggedized miniature instruments meet MIL-M-10304 (Sig. C.) and Salt Spray spec. QQ-M-151A; are available in ranges of 0-100 microamps d-c., 0-1 ma. d.c. and 0-10 mv. d.c.; are designed for a dielectric strength of 1500 volts rms. Lance type pointer and three cardinal points of scale are self-luminous. Accuracy 3 percent of full scale deflection.—*International Instruments, Inc., New Haven, Conn.*

For more information circle **319** on inquiry card.

Multi-range Indicating Instrument

New "555 Multimeter" is metal-cased, provides 43 unduplicated ranges with accuracies of 2 percent d.c., 3 percent a.c. Among features: only two jacks, thereby preventing mistakes and damage and some incorrect readings; 4⅞-in. four-color scales correspond to color coding of function switch; ranges established in 3-to-1 steps.—*Phaostron Co., 151 Pasadena Ave., South Pasadena, Calif.*

For more information circle **320** on inquiry card.

Digital Potentiometer

New "Model 519 Digital Voltmeter" is a self-balancing digital potentiometer for measuring direct voltages from 0.001 to 999.99; has a Weston Standard Cell reference; makes an

average of 75 readings per minute, with automatic indication of polarity and decimal position. Input resistance is in order of 1000 megohms on low range (up to 99.999 volts) and 11 megohms on high range (100.00 to 999.99 volts). Accessories are available for transmitting to remote readouts, as well as for printing, typing or punching permanent records. Instrument weighs 49 lbs.; operates on 115 v.ac.—*Non-Linear Systems, Inc., Box 728, Del Mar, Calif.*

For more information circle **321** on inquiry card.

Digital Voltohmmeter

New "Digital Voltmeter" has a revolving three-digit counter for direct reading of voltage, current or re-

sistance; also an illuminated automatic decimal point and polarity sign. Ranges: 1 mv. to 1,000 v.; 0.001 megohm to 10 megohms. Size: 8½ x 11 x 7½ in.—*Hycon Mfg. Co., 2961 East Colorado St., Pasadena 8, Calif.*

For more information circle **322** on inquiry card.

Digital Indicators

New digital readouts are available with one to six windows, each 1⅝ in. wide by 2 in. high with 1-in. numbers. Edge-lighted engraved Lucite plates are mounted in aluminum frame with miniature bulbs at top or bottom, each numeral associated with a single (removable) bulb. Choice of 6, 14, or 28-

IDENTICAL AMPLIFIERS IN NEW PRECISION CATHODE-RAY OSCILLOGRAPH

THE DU MONT TYPE 340

- Identical, sensitive X- and Y-amplifiers
- Amplifier response dc to 100 kc
- All potentials regulated for stability
- Hard-tube linear sweeps with beam gate
- Mono-accelerator cathode-ray tube for distortionless presentation

Yes, and also precision, simple operation, ruggedness, reliability, ease of maintenance all characterize the *new* Du Mont Type 340 which can well take its place as the oscillograph for those who require the *best* for their important studies.

Identical amplifiers, unexcelled in other commercial instruments, make the Type 340 a powerful tool for measuring electrical phase or mechanical resonance. Controls can be adjusted for less than 1° relative phase shift between amplifiers below 100 kc. Distortion in amplifiers and sweeps is negligible. D-C stability sets new standards. Shifts in level are scarcely observable, even over long periods of operation. The Type 340 truly fits the needs of the discriminating engineer and scientist.

For further information on the Type 340 write to: Technical Sales Department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, New Jersey.

In less than a year you have seen a complete new line of *precision* instruments by Du Mont typified by:

Type 336 CRO	dc to more than 20 mc, high brightness
Type 329 CRO	dc to 10 mc, high voltage
Type 327 CRO	dc to 5 mc, precision calibration
Type 324 CRO	microvolt sensitivity, dc to 300 kc
Type 330	universal electronic switch: dc to 15 mc
Type 300	precision time calibrator

***And now* the Type 340 with identical amplifiers, dc to 100 kc — PRICE $335.00**

TECHNICAL SALES DEPARTMENT
ALLEN B. DU MONT LABORATORIES, INC.,
760 BLOOMFIELD AVE., CLIFTON, N. J.

DU MONT

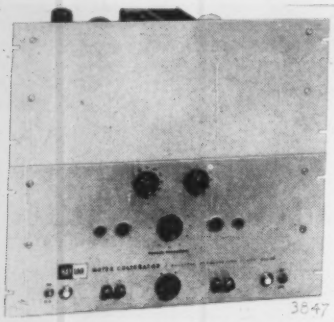
For more information circle **56** on inquiry card.

volt lamps. Letters, etc., on special order.—*Electro Instruments, Box S, Old San Diego Station, San Diego* 10, *Calif.*

For more information circle **323** on inquiry card.

Instrument Calibrator

New combination voltmeter and ammeter calibrator is for use in laboratories and on production lines as a



secondary standard. Stability 0.01 percent; accuracy 0.05 percent.—*Kay Lab,* 1090 *Morena Blvd., San Diego* 10, *Calif.*

For more information circle **324** on inquiry card.

Dual-beam 'Scope

New specialized dual-beam oscilloscope for research is particularly useful in study of long-time phenomena using sweeps up to 10 sec. (200 sec. on special order). Using variable delay trigger, a slowly-moving signal displayed on Sweep 1 can have small detail occurring at mid-sweep displayed on Sweep 2 on a much faster time scale. Amplifier frequency response is flat from d.c. to 100 kc. at 1 volt per inch. Photo recording (single-frame or moving film or paper) is aided by 4000-v. accelerating voltage, sharp focus, and axis shift which, either locally or remotely, changes mode of operation from viewing to recording by stopping sweeps and transferring signals from Y to X axis. Several other features available on special order.—*American Electronic Laboratories, Inc.,* 641 *Arch St., Philadelphia* 6, *Pa.*

For more information circle **325** on inquiry card.

Megohmmeter

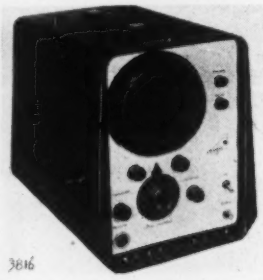
New "Type 1620," for measuring leakage resistance of insulating materials, cables, motors, components,

etc., has d-c. test potential variable from 50 to 1000 v.; reads resistances from 0.1 megohm to 4,000,000 megohms in 6 overlapping ranges.—*Freed Transformer Co., Inc.,* 1715 *Weirfield St., Brooklyn* 27, *N. Y.*

For more information circle **326** on inquiry card.

Signal Generator-'scope

New improved design of "Model 705 Wobbulator" is said to incorporate "several features never found before in equipment of this type." It combines a swept-frequency signal generator with an oscilloscope. Frequency



range 2.0 to 1000 Mc.; continuous single-knob tuning with calibrated dial; amplitute variation less than 0.01 db/Mc.—*Canoga Corp.,* 5955 *Sepulveda Blvd., Van Nuys, Calif.*

For more information circle **327** on inquiry card.

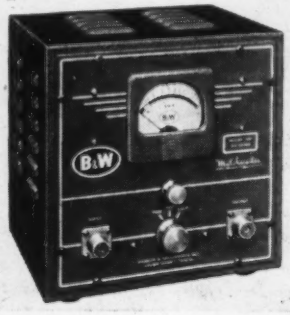
C-r. Oscilloscope

New "Model 320 Wideband Oscilloscope" utilizes identical horizontal and vertical amplifiers which allow phase shift indication for frequencies up to 5 Mc. High deflection sensitivity (35 mv. rms per inch) from 10 cps. to 5 Mc. on both amplifiers, is another feature. Instrument is particularly designed for color TV measurements.—*Crosby Labs, Inc., Box* 233, *Hicksville, L. I., N. Y.*

For more information circle **328** on inquiry card.

Combination Wattmeter

New "Matchmaster" combines all functions of a dummy load, r-f. wattmeter, and SWR bridge. Maximum SWR is 1 to 1.2 over range of 300 kc. to 30

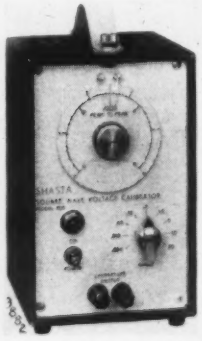


Mc. Two types: "Model 650" for 52-ohm line, and "Model 651" for 73-ohm line.—*Barker & Williamson, Inc.,* 237 *Fairfield Ave., Upper Darby, Pa.*

For more information circle **329** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

CRO Calibrator



New "Model 402 Square Wave Voltage Calibrator" permits calibration of 'scope so that voltage may be read directly from face of tube. It generates a square wave with a constant frequency of 1 kc. and an amplitude which can be continuously varied from 0 to 50 volts: appears as two parallel horizontal lines and distance between them is equal to desired voltage.—*Shasta Div., Beckman Instruments, Inc., P. O. Box* 296, *Station A, Richmond, Calif.*

For more information circle **330** on inquiry card.

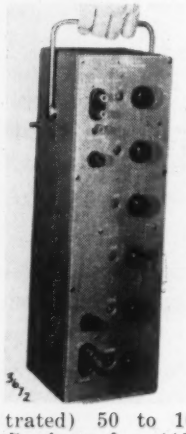
Pulse Oscillator

New "Model 3410A" provides variable repetition rate from 30 cps. to 3 Mc. in five decade ranges. Both posi-

tive and negative pulses are constant width (0.1 usec.) with variable amplitude (max. 30 v.).—*Electro-Pulse Inc.,* 11811 *Major St., Culver City, Calif.*

For more information circle **331** on inquiry card.

Ratio Transformers

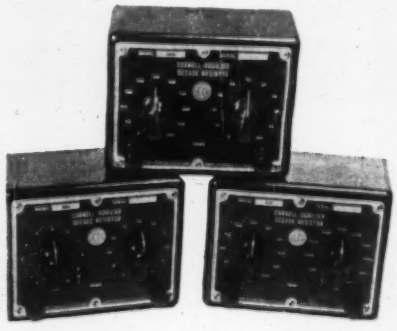


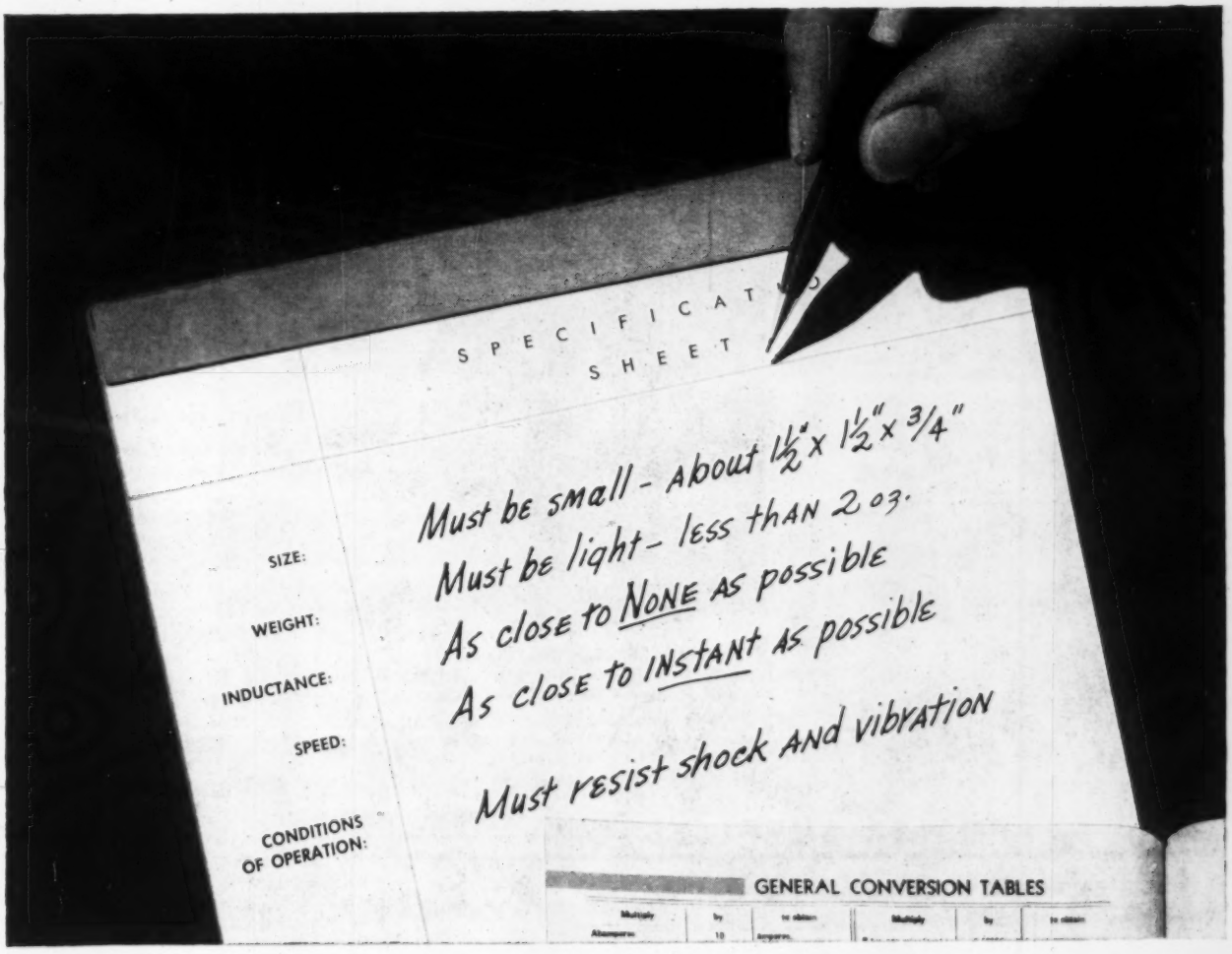
Two new versions of "Standard Ratio Transformer" (a-c. voltage divider) permit rapid selection of accurate voltage ratios by means of rotary switches; feature continuous resolution, readout of better than six significant figures. All switch position digits displayed through dust-proof windows. "PT-4" has a frequency range of 30 to 1000 cps.; "PT-5" (illustrated) 50 to 10,000 cps.—*Gertsch Products, Inc.,* 11846 *Mississippi Ave., Los Angeles* 25, *Calif.*

For more information circle **332** on inquiry card.

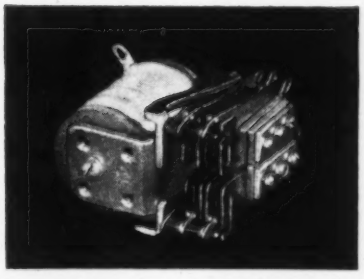
Decade Resistors

New series of three decade resistors provides a source of resistance standards for substitution or test purposes:





When you list these requirements for a relay:



Class S Relays are also available PLUG MOUNTED... to give these additional advantages:

minimized inventory

Manufacturers of process control equipment have standardized on plug-in relays. In that way a manufacturer can interchange the same basic relay in many of its models.

fast, simplified inspection and maintenance

Manufacturers of remote control assemblies specify "plug-in" relays; whole banks of relays can be removed in seconds.

adaptability to hard-to-get-at locations

Manufacturers of machine tools with space problems use "plug-in" relays. Less clearance space is required for installation or removal of relay.

you've specified

the Automatic Electric Class S Relay!

For years the Class S Relay has been meeting conditions like these, and others just as exacting . . . distinguishing itself for dependability . . . amazing users again and again with its stamina.

It's used in aircraft to adjust propeller pitch and synchronize engines, to operate landing flaps and landing gear, to provide automatic pilot equipment with snap and accuracy. It's used in guided missiles. In radio and TV, it is employed to select channels, to repeat pulses. It has hundreds of applications in manufacturing process control, computers, telemetering, automation.

The Class S Relay *probably* has a space-saving, weight-saving, money-saving application somewhere in your products. We'll be glad to send you complete facts and figures on this and the many other Automatic Electric relays. Ask for Circulars 1702 and 1803.

Write: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS **SWITCHES**

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

AUTOMATIC ELECTRIC

CHICAGO

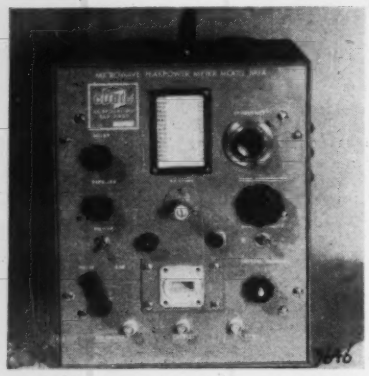
For more information circle **57** on inquiry card.

each unit has two direct-reading panel switch scales in series, permitting 110 different resistance values. "RDA" resistance range 1 to 110 ohms in steps of one ohm; "RDB" 100 to 11,000 ohms in 100 ohms; "RDC" 10,000 to 1,010,000 ohms in 10,000 ohms.—*Cornell-Dubilier Electric Corp., South Plainfield, N. J.*

For more information circle **333** on inquiry card.

Peak-power Unit

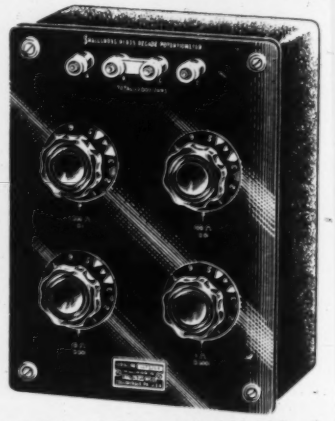
New "Model 100X Microwave Peak-power Meter," used with an external synchroscope and standard wattmeter bridge, provides direct-reading measurements of peak power in X-band transmission systems, at any level up to megawatt region.—*Cubic Corp., 2841 Canon St., San Diego 6, Calif.*



For more information circle **334** on inquiry card.

Decade Voltage Dividers

New laboratory-type decade voltage dividers use Kelvin-Varley circuit. Types offered have total resistances of



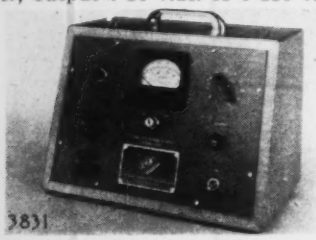
100, 1000, 10,000 and 100,000 ohms with up to six dials. Illustrated: 10,000-ohm "Model 8350" whose four dials permit 10,000 definite increments of input voltage at output terminals.—*Shallcross Mfg. Co., Collingdale, Pa.*

For more information circle **335** on inquiry card.

POWER SUPPLIES

Tubeless Power Supply

New "Model 30 High Current Power Supply" takes input voltage 105-125 v.ac.; output 0-30 v.dc. or 0-130 v.ac.;

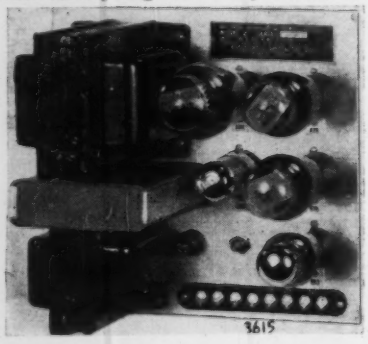


maximum load current 1.5 amps, 30 va. capacity.—*Electronic Research Associates, Inc., 715 Main St., North Caldwell, N. J.*

For more information circle **336** on inquiry card.

D-c. Power Supply

New "Model 2" is a cost-saving subchassis mounting type, 200 to 325 v.dc. closely regulated adjustable output, load current 0 to 100 ma.; also delivers 6.3 v.ac. at 3 amps.—*Associated Specialties Co., 1751 Main St., Orefield, Penna.*



For more information circle **337** on inquiry card.

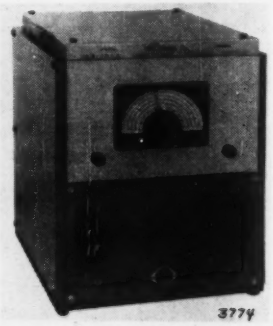
Regulated Power Supply

New "Model 702" delivers output voltages from 0 to 400 continuously variable, with currents up to 200 ma. Regulation 0.5 percent with hum levels less than 20 mv. Variable negative output of 0 to 150 v. is also provided for bias, as well as 6.3 v.ac. at 8 amps.—*Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A, Richmond, Calif.*

For more information circle **338** on inquiry card.

Variable-frequency Supply

New "Model VFS-250 Variable Frequency Power Supply" is a source of 45- to 2000-cps. a.c. with available output up to 300 va. Three main categories of use: (1) testing systems and equipment; (2) powering choppers, vibrators, etc.; (3) controlling synchronous motors and processing equipment.—*Vectron, Inc., 386 Main St., Waltham 54, Mass.*



For more information circle **339** on inquiry card.

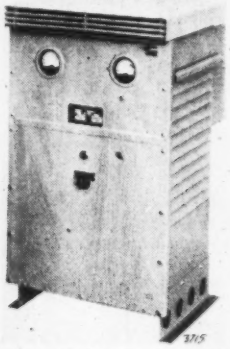
100-amp. Supply

New "Model No. MR2430-100X" is a light-weight (250 lbs.) magnetic-amplifier-regulated (1 percent) 28-v.dc. (24-30-v.) 100-amp. power supply. It contains no moving parts other than cooling fan. Dimensions 25 in. long x 15 in. x 15 in.; response time 0.2 sec.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

For more information circle **340** on inquiry card.

Power Rectifiers

New "Stavolt" units are regulated to 1 percent by a unique magnetic



amplifier control. Ten standard 28-v.dc. models with capacities up to 1000 amps. in mobile or stationary types are available.—*McColpin-Christie Corp., 3410 W. 67th St., Los Angeles 43, Calif.*

For more information circle **341** on inquiry card.

20-amp. Rectifier

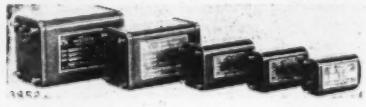
New "Model 1020 F" low-cost bench selenium full-wave rectifier, with continuously-variable output control from zero to full rated power, operates on input of 110-120 v.ac.; rated output 20 amps. 0-10 v.dc. with less than 5 percent ripple; is designed for extra heavy-duty 24-hour operation, 20 percent overload for 2-hour periods. Comes complete with 2-percent accuracy voltmeter and ammeter, pilot light, starting switch, and fuse overload controls. Immediate delivery from stock.—*Rapid Electric Co., 2881 Middletown Rd., Bronx 61, N. Y.*

For more information circle **342** on inquiry card.

AMPLIFIERS

Magnetic Amplifiers

New magnetic servo amplifiers are designed for operation at high temperatures; no rectifiers used. Output power ratings 3 to 40 watts at 400 cps. delivering voltages of 0-26, 0-38, 0-115, and 0-220. Also 60-cps. amplifiers in similar power ratings. Output wave form of these models is sinoidal and phase-reversing according to in-



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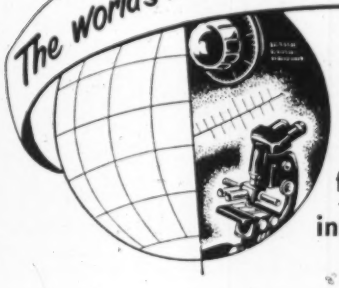

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For more information circle **58** on inquiry card.

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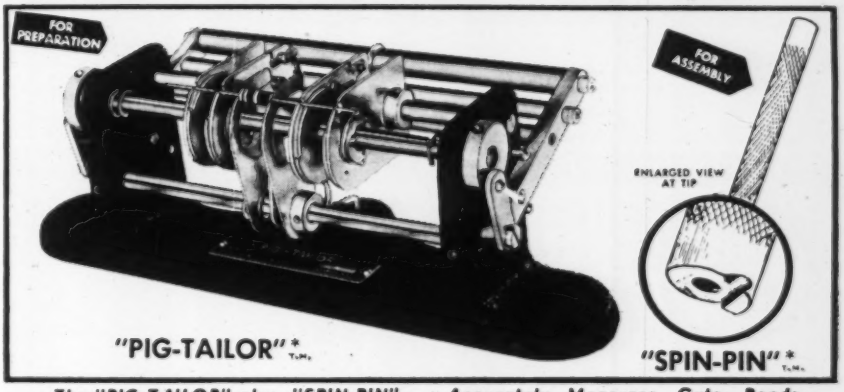

The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

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6. Individual cut and bend lengths.
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2. Long-nose pliers.
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For more information circle **71** on inquiry card.

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For more information circle **59** on inquiry card.

NEW INSTRUMENTS

put. Input signal may be ac. or dc. —*Magnetic Research Corp., 200 Center St., El Segundo, Calif.*

For more information circle **423** on inquiry card.

Electromechanical Amplifier

New "Series 10" electromechanical amplifier for servomotor applications permits a relatively small amount of power, 50 to 100 milliwatts, to control a relatively large motor; features proportional control of output shaft (which will rotate clockwise or counterclockwise as desired); combines planetary gearing and stationary dry magnetic clutches. Rating 5 lb.-in. torque at 60 rpm.; available for most standard line frequencies and voltages as well as various gear ratios.—*Electomic Designs, Greenwich, Conn.*

For more information circle **343** on inquiry card.

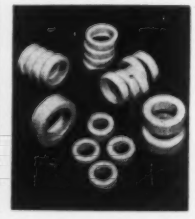
Servo Amplifier

New "Type VA-4-A-60," for 400-cps. operation, features sensitivity and power output said to be available before only in much larger designs. Maximum dimensions 4 x 2⅝ x 1¼ in.; weight 6.6 oz. Unit delivers 4 watts into control phase of a servomotor on an input of 20 mv. Capacitors inside housing balance off reactive component of motor load. Gain may be varied externally. Complete amplifier is capsulated in epoxy against moisture, vibration, etc.; is capable of continuous operation at 85 C. ambient temperature and will withstand 125 C.—*Clifton Precision Products Co., Marple at Broadway, Clifton Heights, Penna.*

For more information circle **344** on inquiry card.

ELECTRICAL AND ELECTRONIC COMPONENTS

Permalloy Powder Cores



New molybdenum-Permalloy powder cores (made under Western Electric license) are immediately available in wide range of sizes; are suitable for use as filters in communications circuits. High *Q* applications, such as filters at frequencies up to 1000 Mc. are among uses.—*Magnetics, Inc., Butler, Pa.*

For more information circle **345** on inquiry card.

High-temperature Rectifier

New type of selenium rectifier will operate in ambient temperatures up to 100 C. (212 F.) without derating and to 150 C. (302 F.) with a moderate amount of derating; is available in all standard cell sizes and circuit arrangements.—*Fansteel Metallurgical Corp., North Chicago, Ill.*

For more information circle **346** on inquiry card.

Adjustable-inductance Ferrite Cores

New ferrite pot core assemblies feature unique simple method for adjusting coils to exact inductance values: slots into which to slide inductance trimming strips consisting of Ferroxcube powder bonded to a plastic strip so that ferrite powder on tape gradually increases in thickness as strip is pulled through air gap, thus decreasing effective gap length. —*Ferroxcube Corp. of America, 43 East Bridge St., Saugerties, N. Y.*

For more information circle **347** on inquiry card.

Junction Transistors

Four new p-n-p junction transistors are announced: "0C70" has a grounded emitter current gain of 20 to 40, "0C71" of 30 to 75; both have average noise figures of 10 db and are excellent for low-level audio applications dissipating 6 milliwatts at 45 C.; are "all-glass" with true fusion seals. "080C" and "081C" are metal-cased and have standard JETEC base and dimensions; metal casing allows a higher collector voltage and a dissipation of 50 mw. at 45 C.; electrical characteristics otherwise same as for "0C70" and "0C71" respectively.—*Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L.I., N. Y.*

For more information circle **348** on inquiry card.

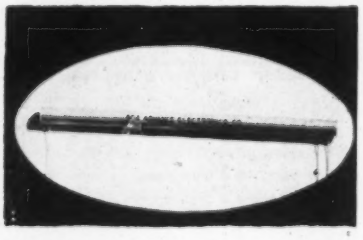
Toroidal Inductors

New toroidal inductors have a standard tolerance of 1 percent, frequency ranges up to 200 kc. and inductance values up to 50 Hy.; available in stabilized and non-stabilized types, standard and subminiature sizes; cased or uncased.—*Freed Transformer Co., Inc., 1715 Weirfield St., Brooklyn 27, N. Y.*

For more information circle **349** on inquiry card.

Miniature Delay Lines

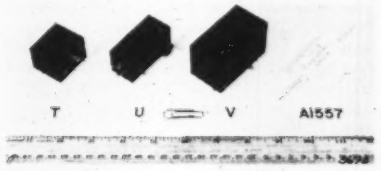
New miniature delay lines meet need of compact delay lines with high impedance, low attenuation, and essentially linear phase characteristics for 'scopes, pulse amplifiers, etc.; are less than 6½ in. long, weigh less than 6 oz.—*Advance Electronics Co., Inc., 451 Highland Ave., Passaic, N. J.*



For more information circle **350** on inquiry card.

Delay Lines

Three new series of military-type delay lines are said to be characterized by superior performance, ability to withstand difficult environmental con-

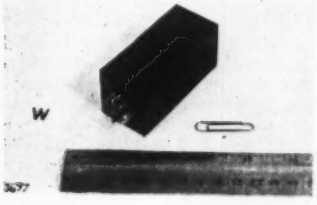


ditions, and excellent thermal coefficients of delay. In each of three new series, a wide range of characteristic impedances and delay times is offered. ★New items in "Subminiature (A1557) Series" of delay lines in range from 2.5 to 0.1 usec.; also a 3.0 usec. line.—*Jacobs Instrument Co., Bethesda* 14, *Md.*

For more information circle **351** on inquiry card.

Tapped Delay Lines

New tapped delay lines are offered in 46 different combinations of delay



times and characteristic impedances; are of military type, designed to withstand extremely difficult environmental conditions. Each line is tapped at 10 equally-spaced points.—*Jacobs Instrument Co., Bethesda* 14, *Md.*

For more information circle **352** on inquiry card.

Pulse Stretcher

New "GPEN-3K-5 Pulse Expanding Network" will generate, in a simple circuit, a 5-usec. pulse with input pulse widths from 0.05 to 2 usec. Output

amplitude can be made to follow input amplitude variations, or may be made to change in proportion to input pulse duration. Impedance is 3000 ohms.—*The Gudeman Co. of California, Inc., 9200 Exposition Blvd., Los Angeles 34, Calif.*

For more information circle **353** on inquiry card.

Long-life Tubes

Eight new "Premium Quality" types of electron tubes, minimum guaranteed life of 10,000 hours, are designed for use in equipment calling for unsupervised uninterrupted operation: 6085 medium-mu dual triode, 6084 pentode amplifier and 6277 output pentode are particularly suited for industrial use; E83F pentode amplifier and E81L

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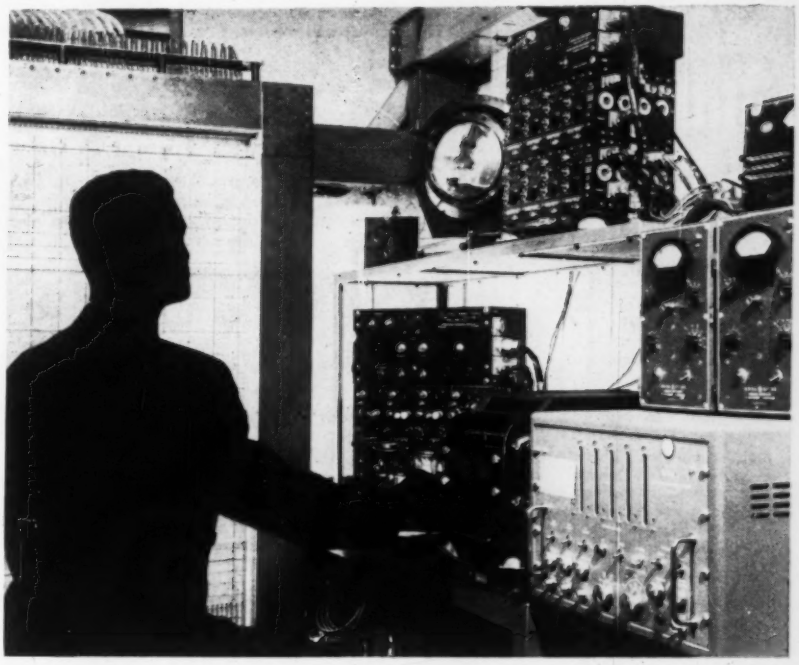

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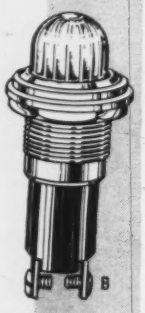
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Let the Dialco engineering department assist you in selecting the *right* lamp and the *most suitable* pilot light for your needs.

Dialco offers the *complete* line of pilot lights, from sub-miniature types to giant units with 1½" lenses.

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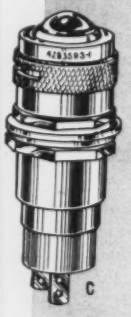
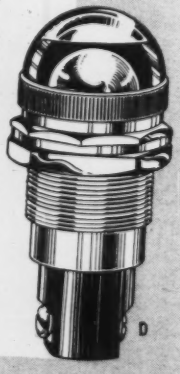

C

Illustrations are approx. 70% actual size . . . *(A)* No. 8-1930-111 sub-miniature pilot light . . . *(B)* No. 521308-991, with multivue cap . . . *(C)* No. 922210-111, dimmer type . . . *(D)* No. 47901 with light shield cap.

Write for Catalogues L-151, L-153, and L-154


D

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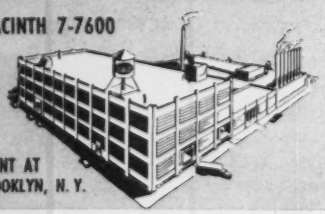

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For more information circle **60** on inquiry card.

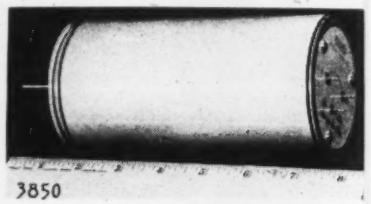
NEW INSTRUMENTS

output pentode designed for telephone equipment and instrumentation; 5920 and E92CC designed for flip-flop circuits in computers, business machines, etc. Tubes' uses, however, are not restricted to these applications.—*Amperex Electronic Corp., 230 Duffy Avenue, Hicksville, L. I., New York.*

For more information circle **354** on inquiry card.

Sixty-turn Linear VDR

New "Resomax Potentiometer" provides a linear (rather than incremental) resistance change with rotation. Resistance ranges 500 to 2000

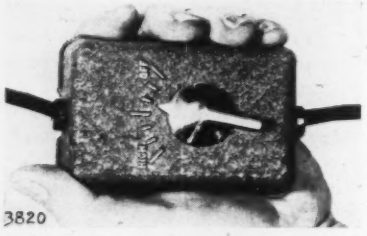

3850

ohms in steps of 500; infinite resolution; normal and zero base linearity 0.02 percent; shaft rotation 60 turns plus 10 minus 0; rating 5 watts at 25 C.—*Link Aviation, Inc., Binghamton, N. Y.*

For more information circle **355** on inquiry card.

Dial-type Rheostat

New "Model D-40" totally-enclosed dial-type rheostat, for hand operation with complete safety, is rated 9 amps.


3820

115 v. ac-dc., 75 to 300 ohms, continuous service. Dial allows selection of 40 different resistance values.—*Colbert Die Cast Co., 5416 Tweedy Blvd., South Gate, Calif.*

For more information circle **356** on inquiry card.

Submin. W-w. Resistors

New subminiature 3-watt wirewound resistors, same size as conventional ½-watt molded carbon resistors (hardly bigger than a match head) are suitable for point-to-point and terminal board wiring as well as on printed wiring boards. Maximum resistance value 10,000 ohms. Tough blue vitreous enamel coating passes stringent humidity tests.—*Sprague Electric Co., 43 Marshall St., North Adams, Mass.*

For more information circle **357** on inquiry card.

Piston Capacitor

New "Model VC-13G" variable trimmer piston capacitor features expansion piston with traverse motion free from backlash (giving smooth capacitance tracking over complete range) and relatively free from effects of vibration and shock. "VC-13G" can operate continuously beyond 125 C. and below –55 C.—*JFD Mfg. Co., Inc., 6101 16th Ave., Brooklyn 4, N. Y.*

For more information circle **358** on inquiry card.

Tubular Capacitors

New "Type P84 CM or Duramics," ceramic-cased paper tubulars, with performance above that of conventional cardboard tubulars, have dense steatite casing, with specially-developed end-sealing material, providing exceptional protection against humidity. Life test is 1½ times rated voltage at 85 C. for 250 hours.—*Aerovox Corp., New Bedford, Mass.*

For more information circle **359** on inquiry card.

Silver-Mica Capacitors

New "Series 46 Jahre" silver-mica capacitors for high-precision test equipment, computers, etc., are available in three grades: "Mica Block" for temperatures from –10 to 60 C. at relative humidities to 80 percent; "Mica Trop," –20 to 70 C. at 100 percent r.h.; "Mica Arkt" series, –55 to 85 C. at 100 percent r.h. Dielectric loss factor is held to less than 10^{-3} through sheet-by-sheet inspection of raw mica. Capacitances from 5 uuf to 0.25 uf available in voltage ratings from 125 to 3000 (working voltages one-third test voltages).—*Arka Imports, 904 San Pasqual St., Pasadena 5, Calif.*

For more information circle **360** on inquiry card.

ELECTROMECHANICAL COMPONENTS

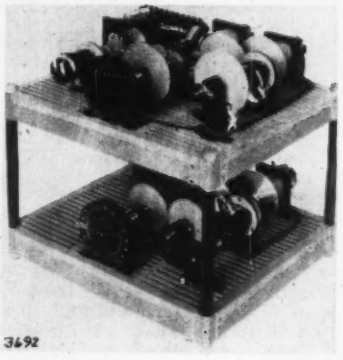
Synchronous Inverter

New "Miniature Syncroverter Switch," non-resonant reed-type inverter, capable of operation over wide frequency and ambient temperature ranges, converts low-power d-c. signals to alternating voltages; is designed for precision requirements of aircraft, computers, null detectors, etc. —*The Bristol Co., Waterbury 20, Conn.*

For more information circle **361** on inquiry card.

Servo-system Components

New grid base plate system for quickly assembling experimental instrumentation systems from stock

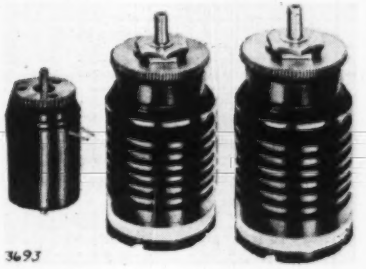

3692

parts requires only ordinary hand tools; construction can be made directly from a rough schematic. Most parts and components, including gears, are so designed that they can be included in final production equipment. Experimental changes can be quickly made and when setup has served its purpose it can be dismantled and parts stocked for future use.—*Instrument Components Inc.*, 14-34 112*th St., College Point, N. Y.*

For more information circle **362** on inquiry card.

Magnetic Clutches

New line of three high-speed precision magnetic clutches are of friction-disc type; torque ratings from 20 oz.-



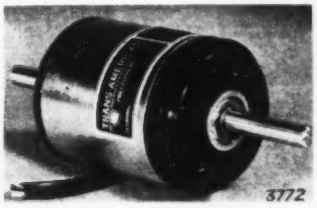
3693

in. to 125 oz.-in.; response times from 0.005 sec. to 0.025 sec.; stationary d-c. coils available in 12, 24, 48, 80 and 175 volts.—*Instrument Components Inc.*, 14-34 112*th St., College Point, N. Y.*

For more information circle **363** on inquiry card.

Magnetic Clutch

New "Model T500," for use in high-accuracy computers, servo systems, etc., passes all military environmental and vibration tests. Among features:



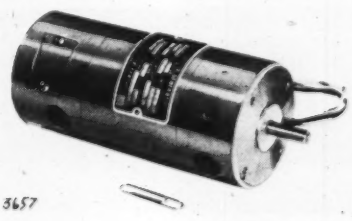
3772

precision ball bearings ABEC 5 used throughout. Endurance: no decrease in performance after one million cycles at 400 per minute with 4 lb.-in. load.—*Trans-American Precision Instrument Corp.*, 34-17 *Lawrence St., Flushing* 54, *N. Y.*

For more information circle **364** on inquiry card.

Motors and Tachometer Generators

New d-c. motor and d-c. tachometer generator combinations are supplied with built-in auto-reset thermal overload protectors (capacitor filters for motor and generator optionally available). Standard motors 5 to 100 watts,



3657

DECADE RESISTANCES & VOLTAGE DIVIDERS

delivered from stock

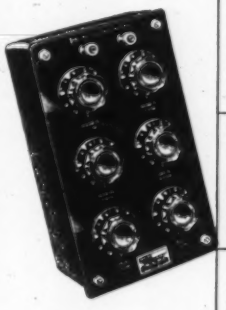
Accuracy: 10 ohms and above: ±0.1%
1 ohm: ±0.25%
0.1 ohm: ±1%
0.01 ohm: ±5%

Temp. Coeff.: ±0.002% per degree C.

Maximum Load: ½-watt per step

Frequency Limit: Non-inductive to 20KC

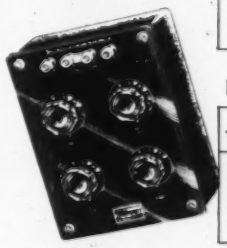
DECADE RESISTANCE BOXES



Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
817	3	0.01	11.1	$60.00
818	3	0.1	111	51.00
820	3	1	1,110	56.00
821	3	10	11,100	60.00
822	3	100	111,000	63.00
823	3	1,000	1,110,000	77.00
824	3	10,000	11,100,000	120.00
817-A	4	0.01	111.1	75.00
819	4	0.1	1,111	71.00
825	4	1	11,110	77.00
826	4	10	111,100	79.00
827	4	100	1,111,000	92.00
828	4	1,000	11,110,000	139.00
8285	5	0.1	11,111	94.00
829	5	1	111,110	101.00
830	5	10	1,111,100	113.00
831	5	100	11,111,000	155.00
817-C	6	0.01	11,111.1	105.00
8315	6	0.1	111,111	109.00
832	6	1	1,111,110	121.00
833	6	10	11,111,100	169.00

UNMOUNTED DECADE RESISTANCES

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
435	1	0.1	1	$12.00
436	1	1	10	13.25
437	1	10	100	13.25
438	1	100	1,000	15.00
439	1	1,000	10,000	16.00
440	1	10,000	100,000	18.50
441	1	100,000	1,000,000	32.50
442	1	1,000,000	10,000,000	60.00



DECADE VOLTAGE DIVIDERS (Potentiometers)

Type	Dials	Ohm Steps	Total Resistance—Ohms	Price
845	3	1	1,000	98.00
837	4	0.1	1,000	126.00
835	4	1	10,000	132.00
836	4	10	100,000	146.00

SHALLCROSS MANUFACTURING COMPANY

510 Pusey Ave., Collingdale, Pa.

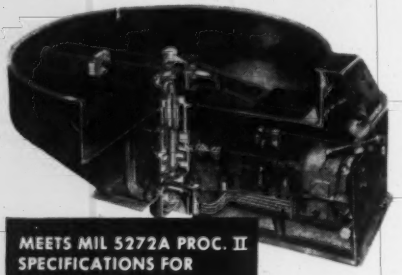
Shallcross

See Us at the I.R.E. Show, Booths 559 and 561 Components Avenue

For more information circle **61** on inquiry card.

GENISCO MODEL B G-ACCELERATOR

A precision centrifuge for testing reliability of electronic components under simulated operational G-loadings



MEETS MIL 5272A PROC. II SPECIFICATIONS FOR ACCELERATION TESTING

Simple operation—To operate, simply mount test object, connect slip rings and accessories, push "start" button and turn handwheel to desired r.p.m. Quick, easy operation makes the Model B particularly suited to large quantity test programs.

Extreme accuracy—The Vickers Hydraulic Transmission provides smooth, constant boom rotation over full r.p.m. range. Wow is less than 0.5% of set speed above 10 r.p.m. Drift at any set speed above 10 r.p.m. is less than 0.1% per minute.

R.P.M. easily measured—A tachometer and timer and counter for measuring rotation rates are standard equipment. A strobe unit which measures exact boom speed (within accuracy of line frequency) at 90 settings over the full r.p.m. range is available as optional equipment.

G-range of 0.017 to 120 G's—Boom rotation speed is infinitely variable from 5 to 420 r.p.m. Radius of gyration ranges from 19" to 24".

Rugged construction—Heavy cast-and-fabricated structure and adequate safety factors assure maximum operator safety, long life, minimum maintenance.

Now four Genisco G-Accelerators!

MODEL NUMBER	G-RANGE	CAPACITY	RADIUS OF GYRATION
B78	0.017 to 120	25 lbs.—8" cube	24"
C159	0.024 to 75	100 lbs.—24" cube	44"
D184	1 to 800	6 1-lb. objects	12"
E185	0.01 to 60	300 lbs.—30" cube	72"

Optional equipment . . . additional internal and overhead sliprings, air system, optical system, and other accessories are available for Genisco G-Accelerators. Write to Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, California, for detailed specifications.

RELIABILITY FIRST

Genisco INCORPORATED

For more information circle **62** on inquiry card.

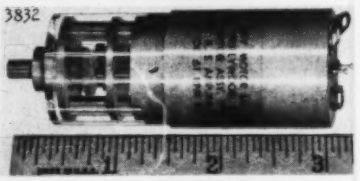
NEW INSTRUMENTS

speeds to 10,000 rpm.; both PM and wound-field types. Standard tachometer output 6 volts per 1000 rpm.—*Electric Indicator Co., Inc., Springdale, Conn.*

For more information circle **365** on inquiry card.

P-m. D-c. Motor

New "Model 1300-1" gear motor, for timing and other devices requiring constant speed, meets or exceeds AN-M-40; can be designed for any input

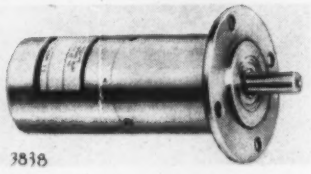


from 6 to 30 v.dc.; output 6 watts maximum continuous duty (12 intermittent); any speed from ½ to 9,000 rpm. depending on gearing.—*El Ray Motor Co., North Hollywood, Calif.*

For more information circle **366** on inquiry card.

Miniature Gear-motors

New subminiature aircraft quality planetary gear reduced motors measure ⅞ in. diam. and weigh as low as

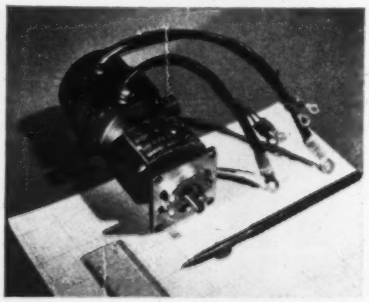


5 oz.; length from 2½ in. to 3 11/64 in. depending on speed reduction ratios. Can be furnished with speed governors (over-all length increased).—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton* 4, *Ohio.*

For more information circle **367** on inquiry card.

Quick-stopping Motor

New "Type PM-4" p-m. motor for 28-v.dc. operation has an integral brake separately actuated from 28



v.dc. and capable of bringing armature to a stop from rated operating speed of 4,500 rpm. within one shaft revolution.—*Dalmotor Co.*, 1344 *Clay St., Santa Clara, Calif.*

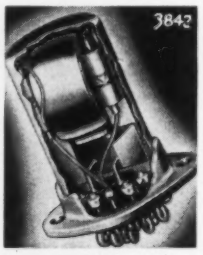
For more information circle **368** on inquiry card.

Synchros

New size 15 synchros are said to feature extremely high accuracies for their size and weight. Max. diam. 1.437 in. and max. over-all length 1.640 in.; average weight 4.7 oz. Units are available as signal generators, receivers, regular and high-impedance control transformers, high-output control transformers, control differentials, regular and high-impedance resolvers, and sine-cosine generators.—*Clifton Precision Products Co., Inc., Clifton Heights, Penna.*

For more information circle **369** on inquiry card.

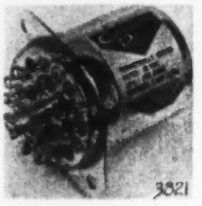
Relay With Built-in Full-wave Rectifier



New "AC-DC Relay" contains four miniature germanium diodes to rectify a-c. excitation signals and provide chatter-free d-c. switching action. Networks of these relays can be operated directly off a-c. power line without need for large d-c. rectifiers; also operate on d-c. excitation of either polarity. Balanced rotating armature withstands 100-*G* shock.—*Hi-G Inc., Bradley Field, Windsor Locks, Conn.*

For more information circle **370** on inquiry card.

Counterpoise Relay

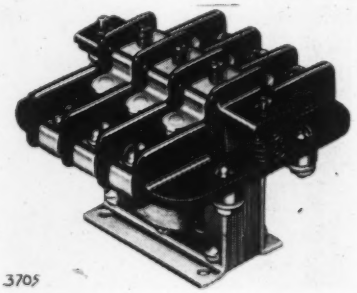


New counterpoise relay utilizes principle of fulcrum and lever with balanced weights so that no motion can take place when relay is subjected to shock or vibration. However, when coil is energized or de-energized, a force couple is produced and rocking motion is transmitted to relay contacts. Among many novel features: Coil space to volume ratio has been increased to 80 percent; sealed assembly is mass-spectrometer leak-tested and pressured with dry nitrogen-helium mixture.—*Diaphlex Div., Cook Electric Co.*, 2700 *N. Southport Ave., Chicago* 14, *Ill.*

For more information circle **371** on inquiry card.

Heavy-duty Relays

New "Part No. 9100" a-c. circuit control relays can handle heavy contact loads (30/20 amps.) with low

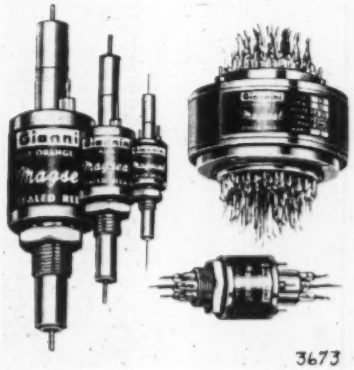


coil power requirements (approx. 25 va.). Insulation, spacing and contact life exceed UL requirements for industrial control equipment. Coils are vacuum varnish impregnated.—*Leach Relay Co.*, 5915 *Avalon Blvd., Los Angeles* 3, *Calif.*

For more information circle **372** on inquiry card.

Sealed-contact Relays

New "Magseals" employ a novel principle: contacting elements sealed in a glass envelope are actuated by an



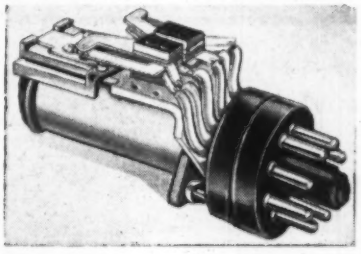
3673

electromagnetic coil mounted about element assembly, have noble-metal contacting surfaces. Coils can be supplied for constant-current or constant-voltage applications. Because of their long life (1 billion cycles), and high switching rates (up to 60 cps.), new relays can be used in high speed switching. —*G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **373** on inquiry card.

Plug-in Relays

New open type plug-in relays can be installed, inspected or replaced without disturbing wiring; can be fur-

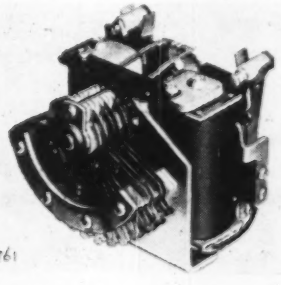


nished with standard contact combinations up to 24 arms per relay. Contact rating 2 amps. at 24 v.dc. or 115 v.ac. Operating voltages from 6 to 230, a.c. or d.c.—*Magnecraft Electric Co., 1442-H W. Van Buren St., Chicago 7, Ill.*

For more information circle **374** on inquiry card.

Stepping Switch

New "Type SS" bi-directional stepping switch, for differential counting, remote selection under control of impulses, and as a digit-storage register in automatic computers, has stepping motor normally equipped with a four-level 12-position bank and wipers; shaft rotated either clockwise or coun-



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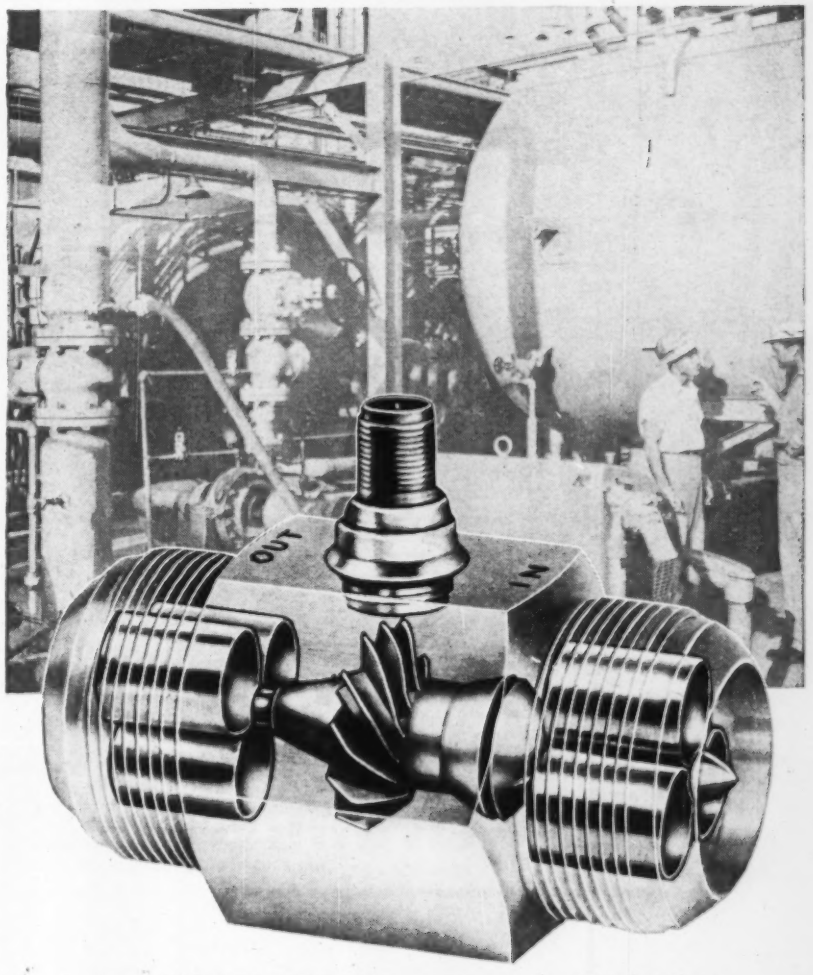

Potter Electronic Flow Meters measure acids, caustics, suspensions at high or low temperatures and pressures with great accuracy!

if the question is flow the answer is Potter

● Potter Electronic Sensing Element with turbine-type "floating rotor" generates current whose frequency is directly proportional to flow rate. Inherently linear element has extremely wide rangeability, low pressure drop.

New Potter Electronic Flow Meters are used for accurate, foolproof, continuous measurement and control of hard-to-handle liquids with an accuracy of ± ½% of true flow over the recommended range. Supplying information in terms of weight or volume, they are efficient at temperatures from —450 to 1200°F and under pressures as great as 35,000 psi. Further advantages are swift, economical installation, low maintenance.

There are complete Potter Flow Meter Systems, including Recorders, Indicators and Digital Totalizers to meet your specific needs.

Write for Bulletin LS-1

Potter **POTTER AERONAUTICAL COMPANY**
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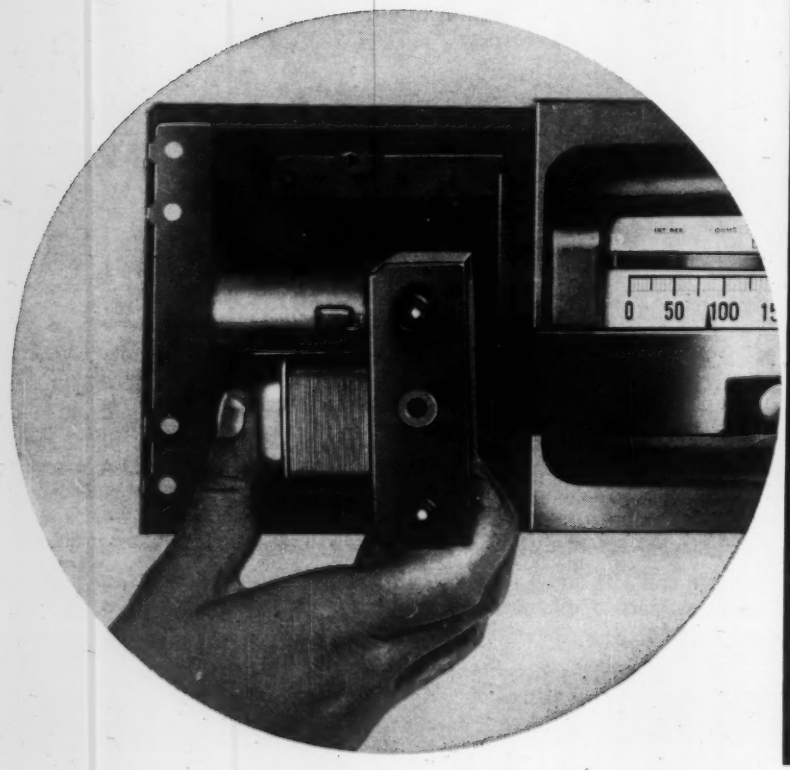
makers of Potter engineered products

For more information circle **63** on inquiry card.

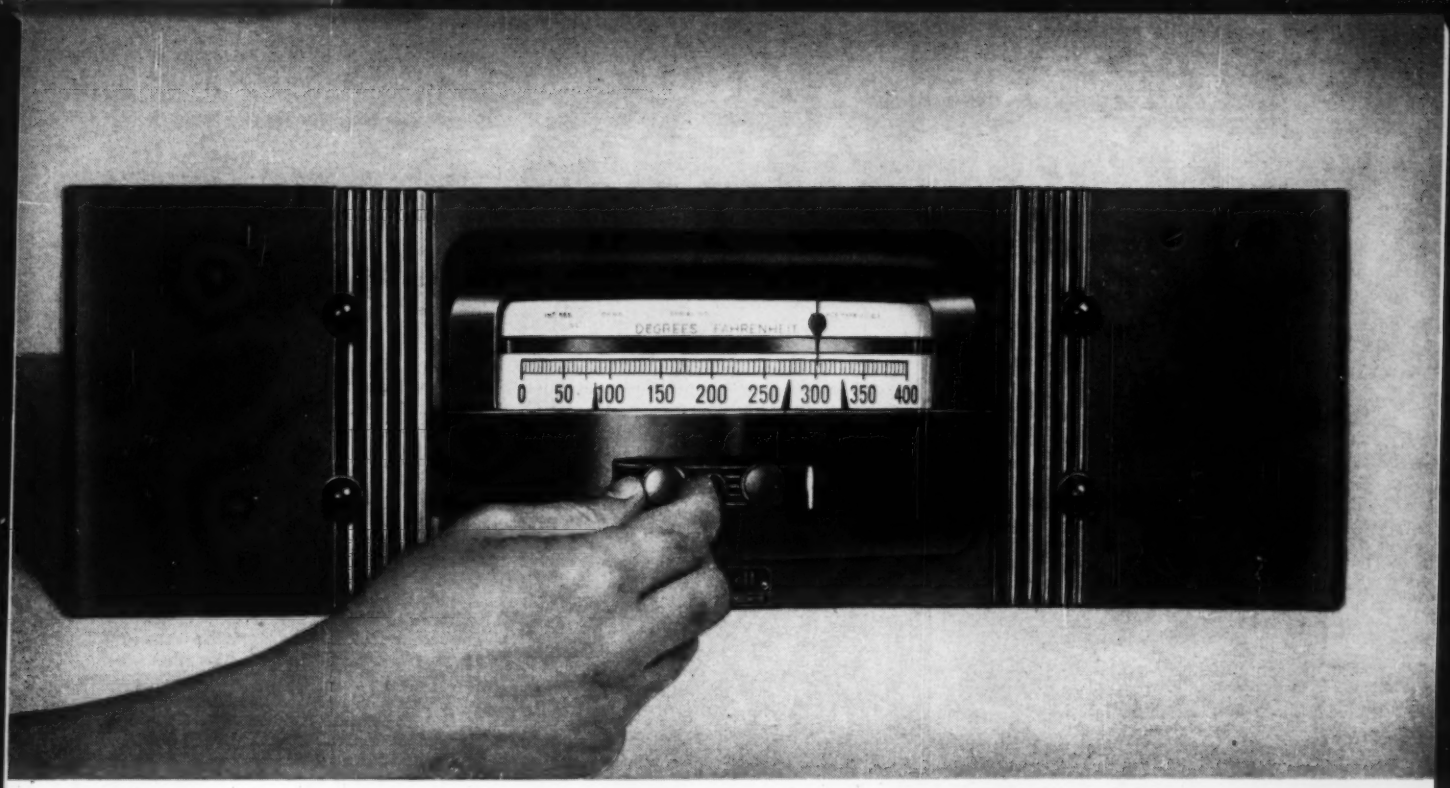
Brand new in performance... versatility... style...

■ the horizontal case



- ***New versatility of control—choose from***
  - —snap-acting on-off control
  - —pulse-type time-proportioning control
  - —three-zone control with dual indexes
- ***New ease of maintenance***
  - —plug-in galvanometer and control units
  - —thermocouple and millivoltmeter can be calibrated without disconnecting wiring
- ***New precision of measurement***
  - —virtually unaffected by ambient temperatures from 50 to 110 F.
- ***New ease of mounting***
  - —19″ wide case fits standard relay racks
- ***New convenience in operation***
  - —signal lights on control unit show high and low control position

For more information circle **64** on inquiry card.



Pyr-O-Vane® Controller

THERE'S more than a new look to this new *Pyr-O-Vane* millivoltmeter temperature controller. Its advanced performance and added features of versatility make it, more than ever, your top choice for economical, dependable control of ovens, furnaces, driers and scores of other kinds of heating equipment.

Its 19-inch wide horizontal case fits standard relay racks . . . permits stacking of controllers in smart-looking central panels. Plug-in unitized sub-assemblies reduce spot maintenance to seconds. Just replace the operating unit with a standby . . . and control continues with practically no interruption.

New refinements give the *Pyr-O-Vane* Controller greater precision and broader flexibility of control than ever before. Its sensitive electronic control can be applied to either fuel-fired or electrically-heated equipment. Your instrument men will appreciate its added ease of calibration and servicing . . . and your production men will like its dependability that stems from long-lasting, precision-made Brown components.

Whether you're modernizing your plant or modernizing the design of heat-using equipment that you manufacture, plan to take advantage of the new *Pyr-O-Vane* Controller . . . and its companion instrument, the new *Protect-O-Vane*® excess temperature safety cut-off. Your local Honeywell sales engineer will be glad to consult on your specific application . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for new Bulletin 1060, "Horizontal Case Millivoltmeter Controllers."**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

H HONEYWELL

First in Controls

For more information circle **64 on inquiry card.**

SERV-RITE

Insulated Thermocouple Wire Extension Lead Wire

FOR

PLATINUM COUPLES
CHROMEL ALUMEL
IRON CONSTANTAN
COPPER CONSTANTAN
IRON CUPRONEL

No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

All Types of Insulation

Felted Asbestos
Asbestos Braid
Weatherproof Braid
Glass Braid
Polyvinyl Plastic
Nylon Braid
Stainless Steel Armored Braid
Silicone Treated
Cotton Braid
Lead Jacket

Ask for Bulletin No. 1200 for Application Data and Complete Specifications on Thermocouple and Extension Wire

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For more information circle **65** on inquiry card.

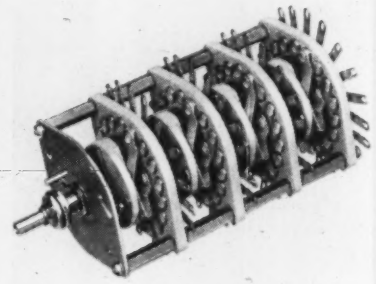
NEW INSTRUMENTS

ter-clockwise in 10-degree increments under control of two electromagnets. Wipers move when coil is energized and cannot be positioned between steps.—*Sterling Engineering Co., 54 Mill Street, Laconia, N. H.*

For more information circle **375** on inquiry card.

Rotary Switches

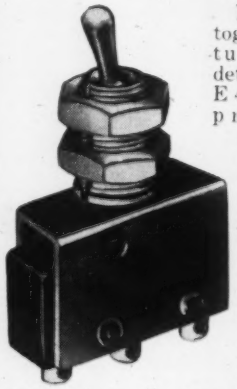
New "12000 Series" oval ceramic switches are said to combine versatility and adaptability of "radio-type" switches with heavy-duty construction of instrument-type switches. Nominal



rating 1 amp., 110 v.ac. At lower currents, or where current is not broken, will handle up to 2500 v.ac.; at lower voltages, currents up to 40 amps.—*Shallcross Mfg. Co., Collingdale, Pa.*

For more information circle **376** on inquiry card.

Miniature Toggle Switch

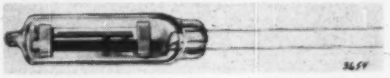


New miniature toggle switch featuring positive detent action has E4-3 MIL-approved basic switch; is available in normally-open or normally-closed s.p.s.t. and s.p.d.t.; rated 5 amps. 125/250 v.a.c. or 4 amps. 30 v.d.c. resistive.—*Electro-Snap Switch & Mfg. Co., 4218-30 W. Lake St., Chicago 24, Ill.*

For more information circle **377** on inquiry card.

Current-limiter Switch

New s-p. s-t. normally-closed hot-wire type of switch limits current flow in a circuit to its nominal critical value. Typical application, protecting



components in radio receivers from overcurrents induced by nearby transmitting equipment. When current exceeds critical point, contacts make and break rapidly, causing current flow through switch to average out at desired preset value.—*Instrument Div., Thomas A. Edison, Inc., West Orange, N. J.*

For more information circle **378** on inquiry card.

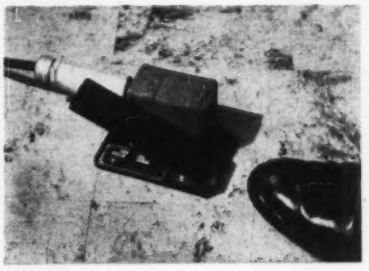
Miniature 5-10-amp. Toggle Switch

New "Type T-2104," two-circuit toggle switch measures 1-5/16 in. long by 15/32 in. diam. but has high current rating (5 amps. inductive or 10 amps. resistive). Cam-roller snap-action mechanism (same as in maker's larger switches) makes it impossible to "tease" the switch on or off contact; cam shape is such that contact pressure is strongest at point of break. Contacts, shorting bar, and terminals are of heavy silver overlay on a copper base.—*Hetherington, Inc., Sharon Hill, Pa.*

For more information circle **379** on inquiry card.

Explosion-proof Footswitch

New "Model 3 Footswitch" comprises UL-approved components for Class I, Group C & D; and Class II,



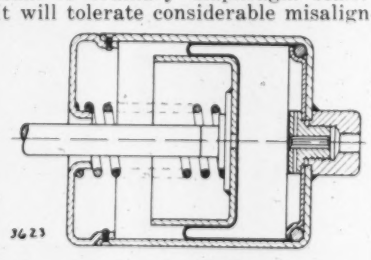
Group E, F, & G hazards.—*Levinthal Electronic Products, Inc., 2903 Fair Oaks Ave., Redwood City, Calif.*

For more information circle **380** on inquiry card.

MECHANICAL COMPONENTS

Power-unit Piston-seal

New "Class 2" of bead-type "Bellofram" with a solid head was developed especially for long-stroke power applications, at pressures up to 500 psi. said to be "up to ten times maximum of ordinary diaphragm seals." It will tolerate considerable misalign-



ment. Among other claimed advantages: leakproof friction-free rolling action, no lubrication, extreme flexing life, resistance to corrosive materials and vibration fatigue.—*Bellofram Corp., 144 Moody St., Waltham 54, Mass.*

For more information circle **381** on inquiry card.

Weighing-system and Power-unit Diaphragm

New "Sensater" is a frictionless stroking diaphragm of new design, for use in high-pressure hydraulic or pneumatic systems, for force measuring, pressure transmission, controlling, and positioning. A 7-in. diaphragm can stroke 5/8 in. and displace

23 cu. in. of fluid. A 25,000-cycle test, stroking 5/16 in. at 500-600 psi. was completed with no sign of failure.—*Martin-Decker Corp.*, 3431 *Cherry Ave., Long Beach, Calif.*

For more information circle **382** on inquiry card.

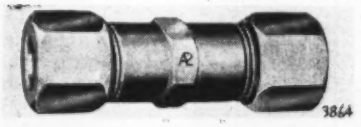
Hose and Couplings

New "Surgepruf" hydraulic hose and couplings are for medium-high and high-pressure service. Couplings, manufactured to J.I.C. standards, feature a "double-wedge" grip enabling assembly on rubber-covered hose without skiving. Slotted bushing enables retightening coupling on hose without disassembly if it comes loose through vibration or flexing. No special tools or mandrels required.—*Joy Mfg. Co., Oliver Bldg., Pittsburgh 22, Pa.*

For more information circle **383** on inquiry card.

Long Union Fitting

New long union fitting, available in "Triple-lok" flare type and "Ferulok" flareless type, has same over-all length



as that of union tee, male outlet tee, and union cross, whence interchangeability.—*The Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

For more information circle **384** on inquiry card.

High-pressure Coupling

New "H Series" coupling, available in sizes ⅛ in. to 10 in. I. D., is said to be "suitable for higher pressure and heavier surge applications than ever before possible." Metal-to-metal valve stop in closed position permits positive control of compression of valve washer sealing member regardless of surge. New coupling retains features of "Hi-Flow" line. "Pass-through" seal principle is also retained. Alloy steel standard; stainless steels and non-ferreous materials to order.—*Snap-Tite, Inc.*, 201 *Kelly St., Union City, Pa.*

For more information circle **385** on inquiry card.

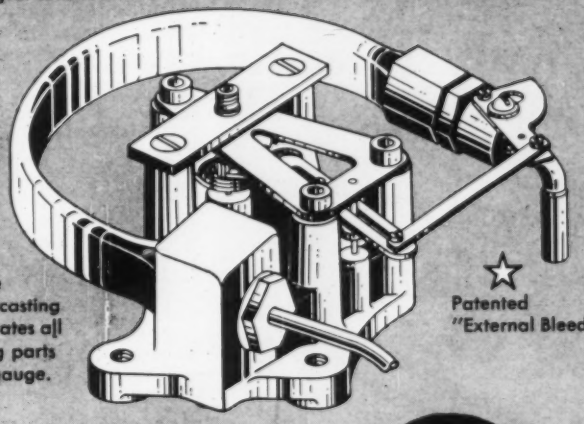
Tube Holders

New Vertical Subminiature Tube Holders will hold up to 5 *G* vibration

HEISE GAUGES

Permanent positive accuracy of alignment guaranteed by integral construction.

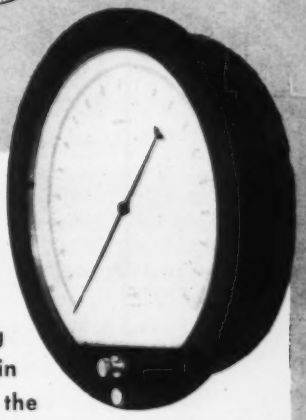
Weldless heat treated Bourdon tube maintains precise calibration.



Massive Bronze casting coordinates all working parts of the gauge.

Patented "External Bleeder"

Dial individually engraved with reference to the pressure gradient of its gauge mechanism.



ACCURACY

The standard of excellence maintained by Heise qualifies this instrument for the most exacting requirements. Designed to maintain permanently its inherent precision, the Heise gauge is often used in place of the dead weight tester in checking other instruments. Consistently accurate performance as a calibration reference has established its recognition as THE STANDARD OF THE WORLD.

SPECIALIZATION AND EFFICIENCY

Heise Laboratories have always specialized in the design and production of high precision pressure gauges. The highest standards of quality control protect the manufacture and assembly of each component and the permanent calibration of the finished instrument.

Efficiency in the production of one type instrument, precision pressure gauges, has made it possible to maintain a prompt delivery schedule.

DELIVERY WITHIN 30 DAYS.

Pressure Range 15 to 20,000 P.S.I.
Dial Sizes 8½"—12"—16"
Prices from $151.60

Catalog on Request

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

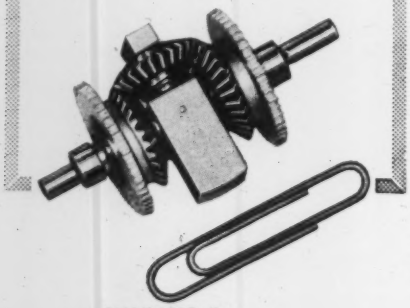
For more information circle **66** on inquiry card.

SINGLE

SPIDER GEAR DIFFERENTIALS

by FORD INSTRUMENT are

7 ways superior



AVAILABLE IN

four sizes: 1/8", 3/16", 1/4", and 5/16" shaft diameters

FOR EARLY DELIVERY

Ford Instrument's single spider gear differentials are engineered to highest military and commercial standards . . . to provide *extreme accuracy* in addition and subtraction, and in servo loop applications.

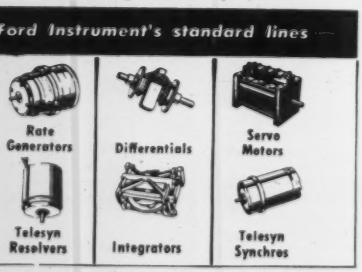
1—High sensitivity.
2—Minimal lost motion.
3—Precision Zerol gears.
4—Corrosion- and wear-resistant materials throughout.
5—Minimum working diameters for compactness.
6—Minimum weights.
7—Rugged, long-life design.

FREE a fully illustrated data bulletin gives performance curves and characteristics. Please address Dept. IA.

42

FORD INSTRUMENT COMPANY
Division of The Sperry Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard lines



For more information circle **67** on inquiry card.

NEW INSTRUMENTS

at 500 cps.; are available for 0.375-in. and 0.500-in. diam.—*Atlas E-E Corp., Bedford Airport, Bedford, Mass.*

For more information circle **386** on inquiry card.

Miniature Connectors

New "Series JF" connectors have countersunk side mounting hole and narrow width to permit exceptionally flat mounting, minimizing connector protrusion when installed on equipment. Contacts are rated 5 amps, use #20 AWG wire, are gold-plated over silver. Minimum voltage breakdown at sea level is 2250 v.dc.; at 60,000 feet altitude, 700 v.dc.—*Winchester Electronics, Inc., Dept. R, Norwalk, Conn.*

3780

For more information circle **387** on inquiry card.

VALVES

Solenoid Valves

3807

New "Bulletin 8265" stainless-steel solenoid-operated ⅜-in. 2-way valves are designed to control fluids generally corrosive to bronze, steel or iron at pressures to 250 psi.; are normally closed (close when de-energized, open when energized); can operate millions of times at a frequency of 400 times per minute. All internal parts accessible without removing body from line.—*Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.*

For more information circle **388** on inquiry card.

Solenoid Valves

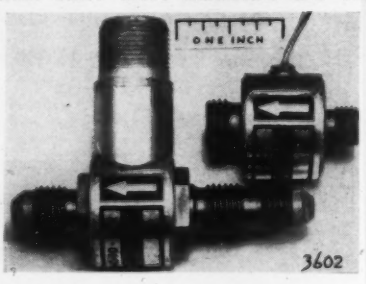
3695

New pilot-operated solenoid valves, available in 30 different models for sizes from ¼-in. to 1½-in., feature use of same coil assembly on all numbers, simplifying servicing and reducing replacement parts inventory. Units available for either a-c. or d-c. operation; bodies for screwed, sweat, or flanged connections; can be installed in horizontal or vertical lines. Maximum differential pressure rating 250 psi.—*Jackes-Evans Mfg. Co., 4427 A Geraldine, St. Louis 15, Mo.*

For more information circle **389** on inquiry card.

Coaxial Solenoid Valve

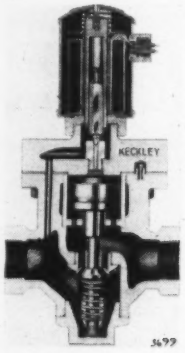
New solenoid-operated shutoff valves are about one-half size and weight of most conventional units because flow passage, valve poppet and valve seat are all within core of coil; may be used with any operating medium since inert materials are employed in construction; are available n-o. or n-c. Units shown have an equivalent flow orifice of 1/32 in. diam. and will open against 200 psi. at 17 v.dc. with 500 F. effluent temperature. —*Dept. EK, Aero Supply Mfg. Co., Inc., Corry, Pa.*



3602

For more information circle **390** on inquiry card.

Solenoid Valves



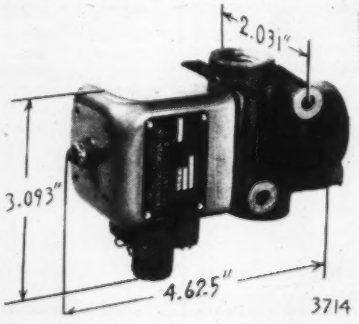
3697

New "Type EA" pilot-operated solenoid valves are designed for steam to 250 psi., or air, water, oil and gas service to 600 psi. Sizes ½-in. to 6 in.; bronze or semi-steel bodies; stainless steel pilot valve, main valve and seat (Teflon seat rings for pilot and main valve seat available for positive shut-off on air, gas and water service). Solenoid coils are glass-insulated moisture-proof type.—*O. C. Keckley Co., 400 W. Madison St., Chicago 6, Ill.*

For more information circle **391** on inquiry card.

Solenoid Air Valves

New solenoid-operated shut-off and selector pneumatic valves for aircraft, guided missiles, and industrial applications feature ease of maintenance. Pressure range from 0 to 3000 psi.; temperature range –65 F. to 265 F. Load is less than 1 amp. at 24 v.dc. continuous duty.—*Mar Vista Engineering Co., 5420 W. 104th St., Los Angeles 45, Calif.*

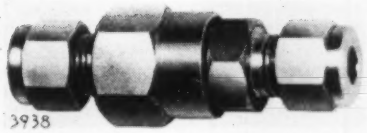


3714

For more information circle **392** on inquiry card.

Check Valves

New "Hoke" check valves with "Swagelok" ends are ball type check valves designed for minimum flow resistance and to provide positive reverse flow check. Synthetic rubber



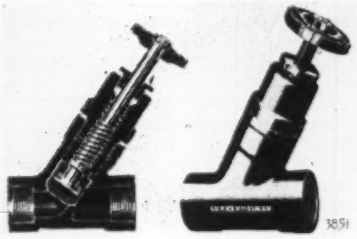
3938

seat; stainless steel spring; fibre gasket. Maximum operating temperature 150 F. Available from stock in brass (1000 psi.) and stainless steel (3000 psi.) or in other materials if ordered in production quantities.—*Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio.*

For more information circle **393** on inquiry card.

PVC Valve and Fittings

New "Luncor" is the first line of all-molded PVC (polyvinyl chloride)



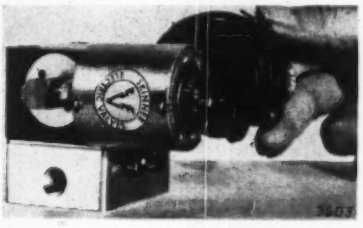
3851

valves and fittings, resisting most chemicals used in industry, and "marketed at a price lower than stainless steel and other alloy valves."—*The Lunkenheimer Co., Cincinnati 14, Ohio.*

For more information circle **394** on inquiry card.

Slide Valves

New "Airswitch" valves, for operating air cylinders, are said to be the first D-slide valves giving multi-million-cycle life and renewable for 25

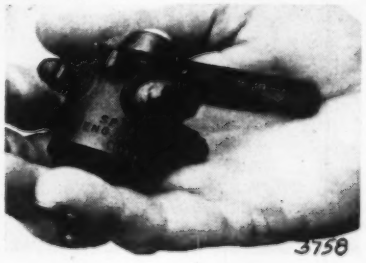


percent of original cost. Balanced type "integral speed throttles" give smooth hydraulic-like action to air cylinders at slow speeds; do not destroy power. Adjustability of both throttles gives wide range of control.—*Airelectric Corp., P.O. Box 208, Melrose Park, Ill.*

For more information circle **395** on inquiry card.

Selector Valve

New "Model S-576" two-position 4-way selector valve for use in low-pressure air or hydraulic systems is leakproof at working presures to 100 psi.; maintains low handle torque; is avail-



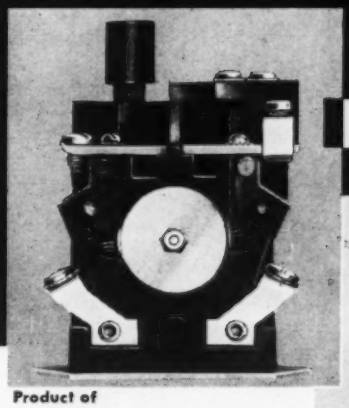
3758

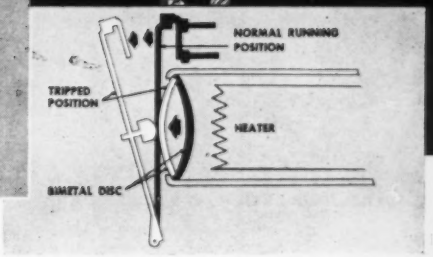
HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

WESTINGHOUSE

Life-Linestarter

OVERLOAD RELAY





Product of Westinghouse Electric Corp., Beaver, Pennsylvania

The Westinghouse Life-Linestarter provides positive protection against dangerous overload and motor burnout. This overload protection is accomplished by means of Chace Thermostatic Bimetal in the form of a snap-action, disc type of overload relay. This is a precision device, more reliable than conventional solder pot type relays since the bimetal disc retains its precise calibration over years of operation and is not affected by oxidation.

HOW IT WORKS

The overload relay is furnished set for hand reset operation. The relay may be set for automatic reset, hand reset or hand reset with no manual means of opening the contacts.

Under overload, the temperature of the heater element adjacent to the Chace Thermostatic Bimetal disc increases. When the temperature rise attains a predetermined level, it causes the bimetal disc to deflect from a normally concave to a convex position. The impact of the disc against the moving contact arm forces the contacts to open and break the coil circuit, opening the starter contacts and stopping the motor. When the bimetal disc cools, it snaps back to its normally concave position. After the cause of the overload has been eliminated, the relay is easily reset and the motor again started. The bimetal disc cannot be damaged by attempted reset at any time during its cooling period.

Chace Thermostatic Bimetal is available in 29 different alloy combinations, in strip, coil or in complete elements, fabricated to customer specification. Send for our new, free booklet, "Successful Applications of Chace Thermostatic Bimetal," containing valuable engineering information for designers of thermally responsive devices.

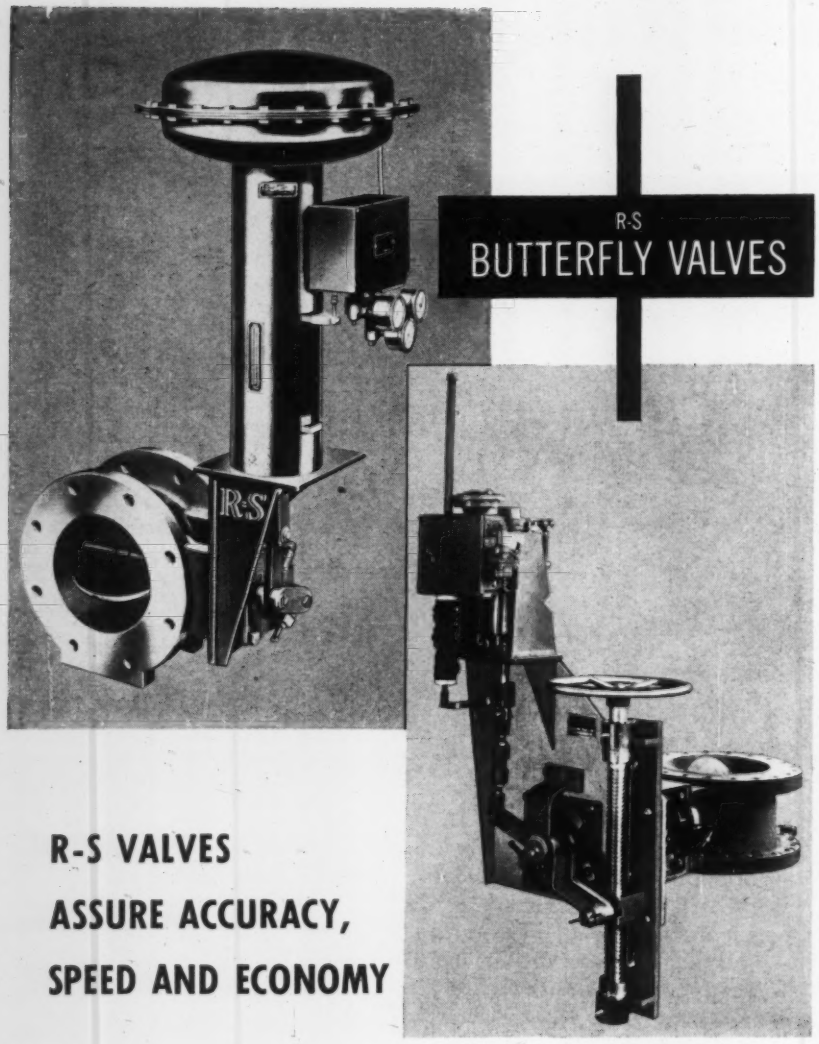
IT BENDS WITH THE HEAT

W. M. CHACE CO.

Thermostatic Bimetal

1609 BEARD AVE., DETROIT 9, MICH.

For more information circle **68** on inquiry card.



R-S VALVES ASSURE ACCURACY, SPEED AND ECONOMY

With automatic controls – R-S Valves will give the most positive and dependable performance obtainable . . .

UNIFORM CONTROL IN ALL POSITIONS . . .
R-S Valves give consistent flow control through all positions in the normal regulating range. The disc simulates a straight line, semi-log characteristic. Cam-driven positioners can furnish other characteristics as required.

REGULATION AND CLOSURE ARE QUICK . . .
Power actuation provides fast or slow regulation-time.

MINIMAL PRESSURE DROP SAVES POWER . . .
In open position the streamlined disc effects less pressure drop than many types of valves. This will show considerable reduction in pumping costs.

S. Morgan Smith offers the best in valve engineering for your control applications. To find the proper valve for any application, or to get additional information on our complete line of butterfly, ball and cone valves, write to the S. Morgan Smith Company, York, Pennsylvania.

Hydraulic Turbines
Pumps
Gates & Hoists
Trash Rakes
Accessories
HYDRODYNAMICS
Rotovalves
Ball Valves
Butterfly Valves
Free-Discharge Valves
Controllable-Pitch Ship Propellers

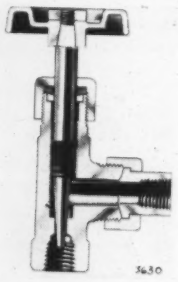
S. MORGAN SMITH CO.

For more information circle **69** on inquiry card.

able in ¼-in. tube size per AND 10056; meets MIL-P-8564. Complete disassembly without disconnecting lines.—*Sprague Engineering Corp., Gardena, Calif.*

For more information circle **396** on inquiry card.

Forged Needle Valves



New "Bull-Dog" forged brass, stainless steel, or carbon steel needle valves feature universal outlets with micrometer thread stainless steel stems for fine metering. Wide range of optional machinings on outlets facilitates low-priced neat installations: no extra charge for optional machining. Also furnished in mountings for instrument panels.—*Carpenter Valve Corp., 6723 Denison Ave., Cleveland 2, Ohio.*

For more information circle **397** on inquiry card.

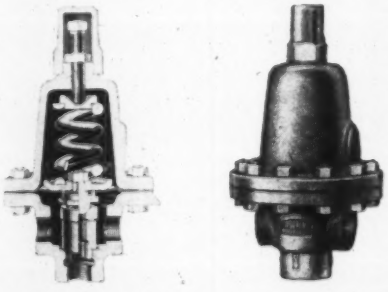
Safety Shut-off Valve

New "Model 350" combination safety valve protects against over-pressure and fuel-fed fires in gas installations; is designed for installation just ahead of gas meters in hospitals, schools, public building, homes, etc.; can be mounted in any position (even upside down); is completely explosion-proof; entire operating head can be knocked off in an explosion and valve remains closed.—*Valco Inc., 1410 West Ave., Cincinnati 15, Ohio.*

For more information circle **398** on inquiry card.

Relief Valves

New "Type FR Back Pressure Relief Valves" are available in pipe sizes from ½ in. to 2 in. in iron, bronze, stainless steel or Monel bodies, for pressures to 400 psi. Unique floating ring principle removes substantially



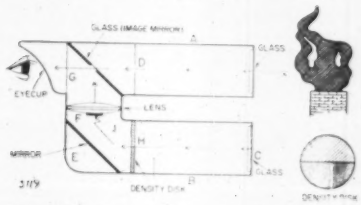
all piston-and-cylinder friction; completely compensates for unavoidable misalignments said to appear in practically every automatic valve.—*A. W. Cash Valve Mfg. Corp., Decatur 60, Ill.*

For more information circle **399** on inquiry card.

MISCELLANEOUS

Smoke Densitometer

New "Smokescope" aids fuel efficiency as well as compliance with smoke control laws; enables observers to view a standard reference disk, shaded to correspond with degrees of

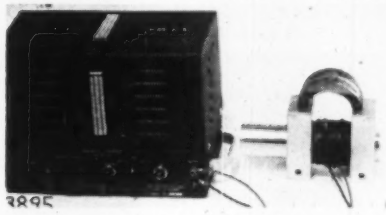


smoke density, against background of a smoke plume; obviates difficulties surrounding old method based on "smoke chart" at 50 ft. Design eliminates possible interference of ambient light because observer views smoke through apertures which limit field of vision to subject; and no need to shift eye from smoke to chart, since chart appears against smoke being viewed. —*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh 8, Pa.*

For more information circle **400** on inquiry card.

Magnet Charger

New "Model 1601" light-weight pulse-type magnet charger utilizes an external coil and pole-piece to charge

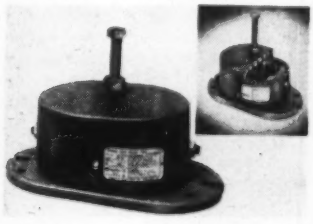


small magnets; can also be used to charge magnets remaining in equipment where a suitable coil is a part of equipment. Normally operated from 115 v.ac. but can also be battery-operated as a portable unit.—*Geotechnical Corp., 3712 Haggar Drive, Dallas, Texas.*

For more information circle **401** on inquiry card.

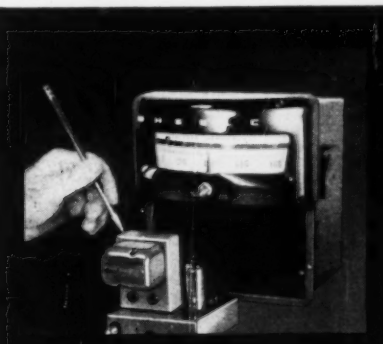
Vibration Mounts

New "Type SF" fully-enclosed spring type vibration isolating units are of telescopic construction; offer increased carrying capacity without increase in physical size; come factory pre-set but may be readjusted in the field. Resilient guides contained within upper portion of housing offer all-direction snubbing and damping. Among other features: Inspection windows; combination adjustment and leveling bolt for loading springs and

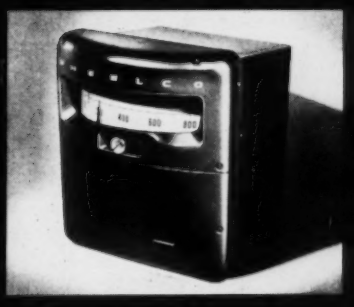


BARBER COLMAN

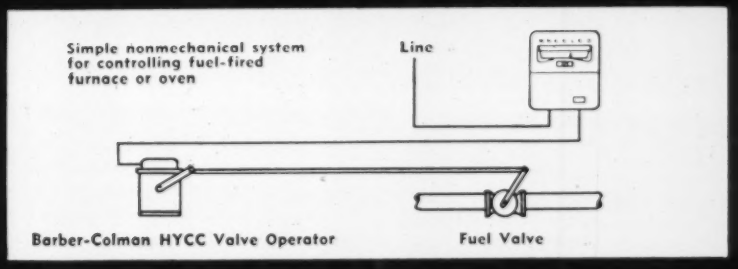
NEW Wheelco Model 405 Capacitrol



"Micropositioner" eliminates slide-wires

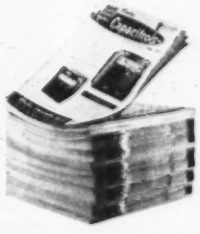


Modern design . . . new control concepts


Simple nonmechanical system for controlling fuel-fired furnace or oven
Line
Barber-Colman HYCC Valve Operator
Fuel Valve

Exclusive Wheelco development improves and simplifies proportioning control!

Ready right *now* for immediate delivery to you is the *all-new* Wheelco Model 405 Capacitrol that is causing more country-wide interest than any new instrument in years . . . the only truly simplified, entirely non-mechanical proportioning control form for fuel-fired equipment . . . the first completely modern controller that gives you all latest instrument design features at a real money-saving price. An ultra-sensitive polarized relay for positioning the control valve actuators, Wheelco's new "Micropositioner" is an integral part of the "plug-in" *electronic* circuit . . . a stand-out feature that gives you *true* proportioning control without complex equipment!



Write for complete facts

Write or ask your Wheelco Representative for Bulletin F-6493 . . . the complete story of the pace-setting changes this new Capacitrol brings to instrument users.

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For more information circle **402** on inquiry card.

Direction-finding System

New radio direction finding system for use at civil and military airports enables control tower operators and flight dispatchers to obtain bearings instantly during every radio contact with an airplane. No additional operating personnel is needed, since receivers are pretuned, operation is fully automatic and antenna site is unattended. New system is available with full remote control for both HF and VHF operation on any desired number of crystal-controlled channels.—*Servo Corp. of America, New Hyde Park, N. Y.*

For more information circle **403** on inquiry card.

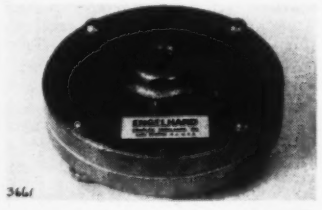
Air-lane Beacon Control

New version of maker's combination "Photo-electric Control and Beacon Flasher Unit" allowing greater freedom and flexibility in installation is available in three models to handle tower lights of 2, 3, 4 and 5 light-level categories. Line relay is of mercury plunger tube type, and mercury tilt-switches are employed in flasher mechanism.—*Hughey & Phillips, Inc., 3300 No. San Fernando Blvd., Burbank, Calif.*

For more information circle **404** on inquiry card.

Gas Filter

New filter-unit removes all traces of liquid or solid particles contaminating a gas. Effectiveness: it extracts all traces of cigarette smoke. Standard



filter material is unaffected by temperatures up to 300 F.; high-temperature (1200 F.) material discs also available.—*Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.*

For more information circle **405** on inquiry card.

Ceramic-to-Metal Seals

New line of "Advac" hermetic seals capable of withstanding high temperatures (1400 F.) and severe thermal shock are result of integration of metal coating into ceramic itself. Complete line of standard terminals is available; custom seals fabricated for special requirements; complete assemblies, including cover plates, available. —*Advanced Vacuum Product Inc., 18-22 Liberty St., Stamford, Conn.*

For more information circle **406** on inquiry card.

Thread Lubricant

New thread lubricant for use on titanium, stainless steel and aluminum is available in two grades: "Blue Goop" for temperatures up to 400 F. eliminates galling so threads can be reused; "Silver Goop" for temperatures up to 2100 F. is an antiseize compound.—*Crawford Fitting Co.*, 884 *E. 140th St., Cleveland* 10, *Ohio.*

For more information circle **407** on inquiry card.

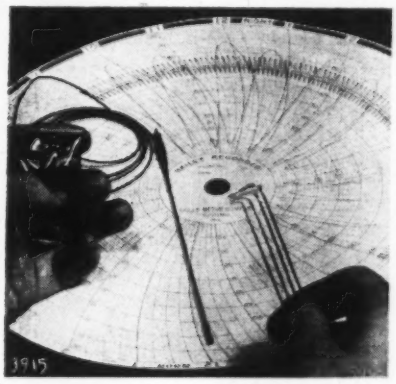
Pilot Light

New two-terminal sub-miniature pilot light is fully insulated; provides omnidirectional visibility; mounts in a single 15/32 in. clearance hole; is designed to employ any of five standard midget flanged base incandescent lamps of voltages 1.3; 2.7; 6.0; 14.0; and 28.0. "Omnidirectional" visibility cap may be one of three types: (1) non-diffusing (transparent); (2) light diffusing; (3) completely diffusing. Clear, or any of 6 colors.—*Dialight Corp.*, 60 *Stewart Ave., Brooklyn* 37, *N. Y.*

For more information circle **408** on inquiry card.

Recording Pen

New featherweight stainless steel capillary pen is fed from a clear hermetically-sealed plastic ink sac containing over a year's supply. Capillary

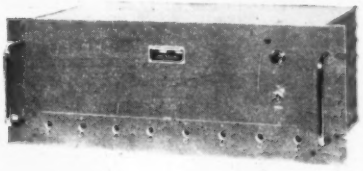


flow to precision-ground point traces a sharp opaque quick-drying record. "Poisoning" of intersecting records is practically eliminated. Up to four pens trace on parallel time arcs 0.042 in. apart. Pens have run on equivalent 15-year accelerated tests at ambient temperatures from 20 F. to 140 F. without breakdown or appreciable wear.—*Bailey Meter Company*, 1050 *Ivanhoe Road, Cleveland* 10, *Ohio.*

For more information circle **409** on inquiry card.

Receiver Multicoupler

New "Type AM-1 Receiver Multicoupler" couples eight receivers to one antenna with practically perfect isola-



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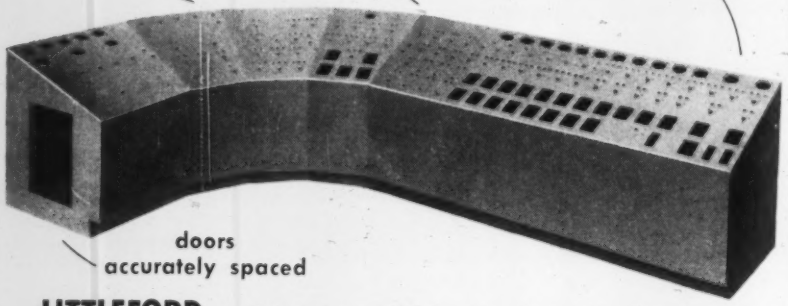

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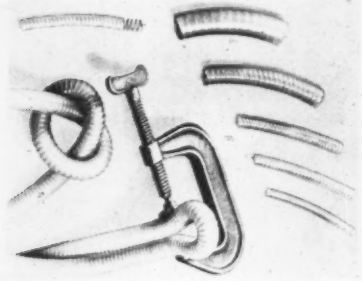
NEW INSTRUMENTS

tion between receivers.—*Clarke Instruments Div. Nat'l Electrical Machine Shops, Inc., 919 Jesup-Blair Drive, Silver Spring, Md.*

For more information circle **410** on inquiry card.

Plastic Tubing

New "Armourvin" industrial piping is made of translucent plastic, features unique "molded in" wire which is kept



from contact with liquids or gases inside or outside. ★A variation, "Armorflow," is especially resistant to gasoline, etc.; can handle boiling water; is fully flexible at –20 C. and up to 150 C. Neither tubing will support combustion.—*Newage International, Inc., 235 E. 42nd St., New York 17, N. Y.*

For more information circle **411** on inquiry card.

Plastic Sealer

New "Model 354 Electromag Magnetic Bar Heat-Impulse Sealer" is arranged to leave both hands free for

accurate positioning of plastic products being sealed, uses magnetic closing of a hinged pressure bar to provide secure clamping.—*Electronic Processes Corp., 1137 San Antonio Road, Los Altos, Calif.*

For more information circle **412** on inquiry card.

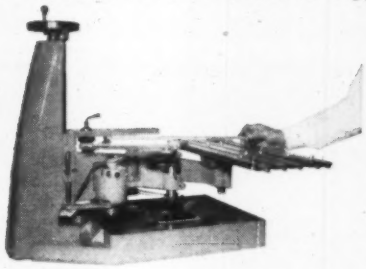
High-strength Adhesive

New "A-6" adhesive enables bonding of aluminum to aluminum and joining of hard-to-bond metals; requires only contact pressure for joining; cures at room temperature. It will also bond wood, plastics, glass and hard rubber to themselves and to one another. Shear tests often exceed 3000 psi. at room temperature. Curing takes from 1 to 36 hours, depending upon temperature. Adhesive does not shrink, swell or creep.—*Armstrong Products Co., Box 1-N, Warsaw, Indiana.*

For more information circle **413** on inquiry card.

Heavy-duty Engraver

New heavy-duty pantograph engraving machine, specifically developed for engraving large-size or bulky work pieces, offers an infinite number of reduction ratios from master copy

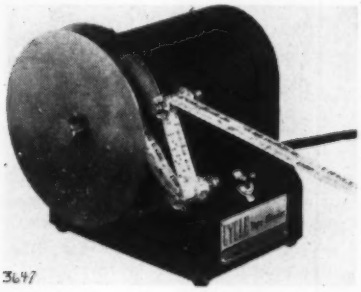


(from 2 to 1 to infinity). Single handwheel control easily adjusts both master copy and cutting tool vertically in increments of 0.001 in. As machine is open and unobstructed on all three sides, it permits engraving up to 15 in. from outer edge of a panel of any size. Circles up to 7 in. diam. can be engraved at 2-to-1 ratio.—*Green Instrument Co., 385 Putnam Ave., Cambridge, Mass.*

For more information circle **414** on inquiry card.

Tape Winder

New "Model TE Tape Minder" for perforated-type equipment features automatic intermittent power winding and constant gentle tape tension. It



3647

receives tape from above or below, right or left side, and will coil it clockwise or counterclockwise. It reduces service troubles on other equipment by keeping tape off the floor.—*Cycle Equipment Co., 461 Market St., San Francisco, Calif.*

For more information circle **415** on inquiry card.

Shatterproof Plastic for Instrument Panels, etc.

New "Gravoflex," said to be the first truly flexible laminated plastic, offers a combination of beauty, strength, and toughness; will not break or chip; can be bent to any angle or form to follow shape of any instrument housing. Fine-grained, leather-like and scratch-resistant surface does not need any further finishing. Panels made of "Gravoflex" reduce weight of instrument because it is 27 percent lighter than laminated phenolic, and 62 percent lighter than aluminum. "Gravoflex" is laminated in layers of two contrasting colors, in a variety of combinations. When engraved through top layer, lettering stands out permanently and does not need filling-in with paint. Whereas fabricating laminated phenolic requires expensive carbide-

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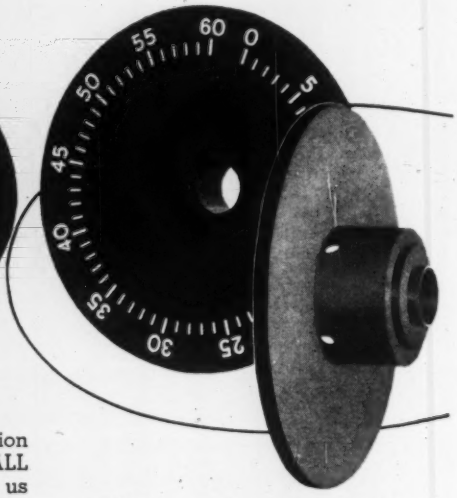

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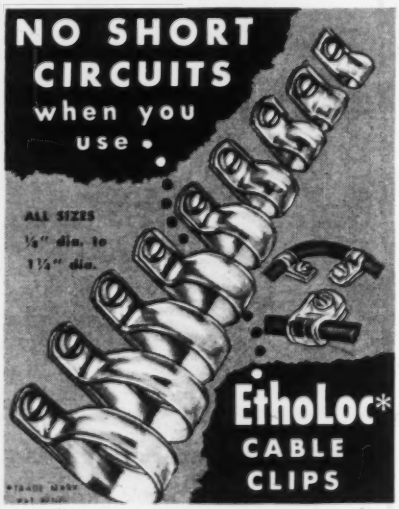

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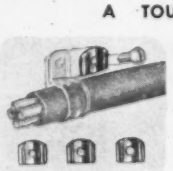

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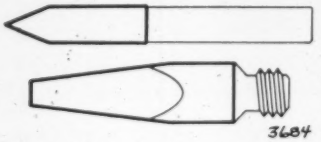
NEW INSTRUMENTS

tipped saw blades and tools, "Gravoflex" can be sheared, die-cut, or punched, riveted, nailed, stapled, stitched or cemented. It is stain- and moisture-resistant and has excellent dielectric properties. Standard thicknesses 1/32, 1/16 and ⅛ in.—*Hermes Plastics, Inc.*, 13-19 *University Place, New York* 3, *N. Y.*

For more information circle **416** on inquiry card.

Soldering Iron Tips

New "Long-Life Hexclad" tips are said to "outlast plain copper tips as much as ten to one with practically no

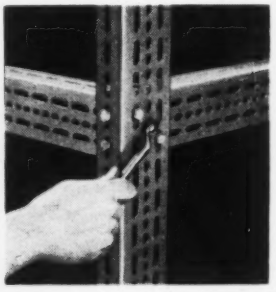


loss of heat"; have a heavy coating of iron alloy over copper base on all exposed surfaces; are furnished tinned ready to use. All sizes.—*Hexacon Electric Co.*, 295 *W. Clay Ave., Roselle Park, N. J.*

For more information circle **417** on inquiry card.

Slotted Angle System

New "Flowstrut" enables rapidly constructing, from rough sketches, industrial structures "from workbench

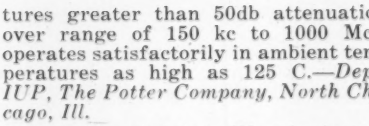


to warehouse," including instrument requirements. Basic components: slotted steel angle bars of 14-gage steel supplied in 12-ft. lengths, predrilled with 40 bolt holes per foot; 20-gage steel panels supplied in four sizes (9-in. and 12-in. depths, 36-in. and 48-in. lengths); reinforced when necessary with panel stiffeners available in 36-in. and 48-in. lengths.—*Flowstrut Corp.*, 141 *East 44th St., New York* 17, *N. Y.*

For more information circle **418** on inquiry card.

Motor Noise Filter

New miniature molded radio noise filter, designed to fit a small motor and gear assembly, reduces over-all filter length approx. 50 percent; fea-



tures greater than 50db attenuation over range of 150 kc to 1000 Mc.; operates satisfactorily in ambient temperatures as high as 125 C.—*Dep't IUP, The Potter Company, North Chicago, Ill.*

For more information circle **419** on inquiry card.

Hand Microscope

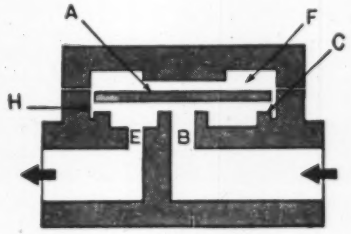
New "Pandux" 6× general-purpose two-element magnifier has a perfectly flat field of 13/16-in. diam. Features:

eye-to-object distance is at least 3 in.; no color aberration; no spherical aberration.—*Pacific Transducer Corp., 11921 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle **420** on inquiry card.

Steam Trap

New Thermodynamic Steam Trap utilizes novel principle: kinetic energy of steam closes valve. This permits an extremely simple design. Only moving part is valve head (A); same head and seat are used for pressures to 600

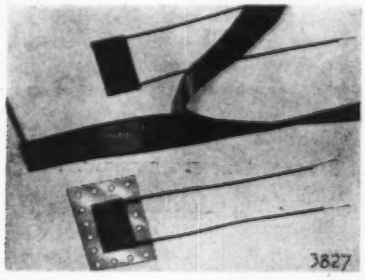


psi. and temperatures to 950 F. Trap closes tight on no load; operates against back pressure up to 50 percent of inlet pressure; discharges condensate at saturated steam temperature as rapidly as it forms; is designed to work as efficiently at 1 psi. as at 600 psi.; is not affected by pressure variations.—*Dep't P, Sarco Co., Inc., Empire State Bldg., New York 1, N. Y.*

For more information circle **421** on inquiry card.

Flexible Electric Heating Elements

New electric heating elements, formed as flexible blankets or strips, are also offered with a perforated



stainless steel backing. Insulation is silicone rubber and Fiberglas cloth.—*Electro-Flex Heat, Inc., 516 Asylum St., Hartford 5, Conn.*

For more information circle **422** on inquiry card.

Tube Race—the latest addition to the Instrof System of INSTRUMENT TUBING SUPPORT

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Instrof, the completely prefabricated method of supporting Instrument Tubing announces Tube Race, a simple channel section, specifically designed to provide an inexpensive yet permanent means for supporting and protecting a limited number of tubes in branch runs to and from the "Main Line" Instrof System.

Basically, Instrof Tube Race is a channel equipped with tube clips permanently installed during manufacture. It is designed to accommodate from two up to six ¼" tubes or three or four ⅜" tubes.

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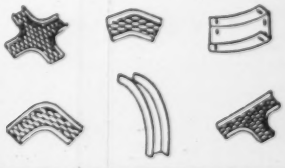

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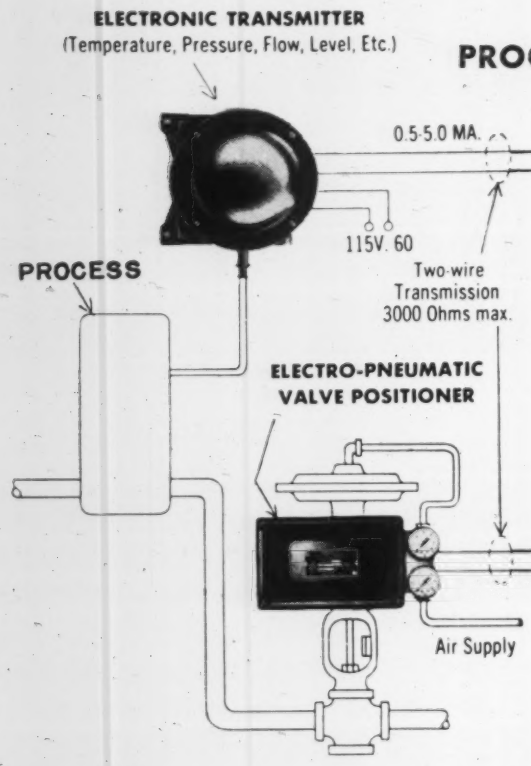

Advantage of ELECTRONIC

INSTANTANEOUS TRANSMISSION

C. E. MATHEWSON

Manning, Maxwell & Moore, Inc.

CONVENTIONAL CONTROL SYSTEM (above) comprises a pickup and transmitter (in the process area) for measurement of the variable, a communication line from the transmitter to the controller and recorder (in the control area), another communication line from the controller to the control valve (in the process area), and the process itself, which closes the control loop. The degree of control obtainable is related to the frequency response of every element in the control loop.

Loop Gain and Stability

The gain of a control system is the ratio of the output to the input. Both open-loop and closed-loop gains depend on the frequency response and phase shift associated with each element in the control loop.

The open-loop gain of the system is the ratio of output to input when the loop is open. This can be found by placing the primary element in a test chamber (rather than in the process), and artificially varying the test chamber at various frequencies. Each change in test-chamber variable will produce a corresponding change in process variable. The ratio of the latter to the former is the open-loop gain. If the response of the primary element can be neglected, it is simpler to open the loop by disconnecting the primary element from the transmitter, and then vary the input to the transmitter in some arbitrary manner.

For closed-loop gain, the system is set up in conventional controlling manner. Then the set point on the controller can be varied sinusoidally at various frequencies. The ratio of the amplitude change in controlled variable to the change in set point at any one frequency is the closed-loop gain at that frequency.

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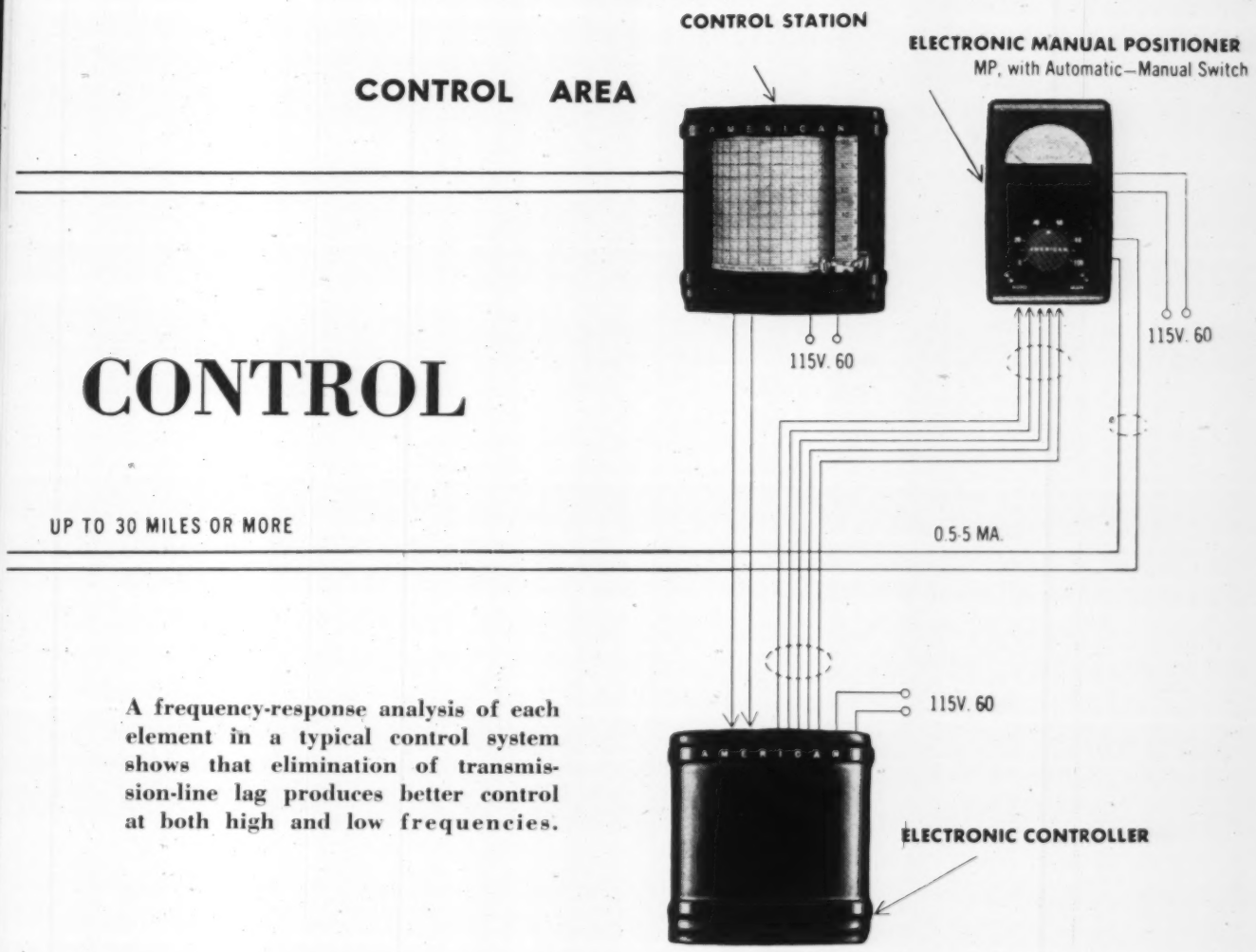
When the loop is closed, changes in the controlled variable cause *corrective* valve action that opposes the original deviation from control point. It is desirable to have as large a corrective action as possible—that is, the open-loop gain should be as high as possible to minimize deviations from the control point. If there were no phase shifts or time lags of any type in the system, the open-loop gain could be made infinite; no deviation from control point then would be possible because the slightest deviation would produce infinite corrective action. The closed-loop gain would then be unity (or zero db).

However, there are always lags present in the system. The inherent lags in each element in the control loop (including the process) cause phase changes so that the valve action is never *exactly* corrective—that is, the valve action is never *exactly* 180 degrees out of phase with the variable. As the frequency of the variation increases, the valve lags further and further behind its desired phase—and when it lags by an additional 180 degrees it reaches a phase of 360 degrees *behind* the variable. When this happens it is not only not corrective, but it is now in a direction to make the deviation worse. *If the open-loop gain is unity (or greater) at the frequency at which the valve is lagging by this unwanted 180 degrees, the system oscillates.*

Stability Criteria

A closed-loop control system exhibiting unity gain (open-loop gain) and 180-degree phase lag is naturally unstable. These are the two criteria of stability: the open-loop gain must be less than unity at the frequency at which the phase lag is 180 degrees. Restated differently: the phase lag must be less than 180 degrees at the frequency at which the open-loop gain is unity. (Unity gain is zero db.)

CONTROL



A frequency-response analysis of each element in a typical control system shows that elimination of transmission-line lag produces better control at both high and low frequencies.

A system that is almost, but not quite, naturally oscillatory suffers from damped oscillations when disturbances occur. To minimize these oscillations a safety margin of stability is provided by general agreement. That is, for good stability a phase lag of less than 135 degrees, *or* an open-loop gain of less than 1/3 is desirable (rather than 180 degrees and unity gain). Restated differently, either a *phase margin* of 45 degrees or a *gain margin* of about 8 db is desirable. The phase margin is the safety factor in phase at the point where the gain is critical (drops to unity); the gain margin is the safety factor in gain at the point where the phase is critical (becomes 180 degrees).

Control Modes

General-purpose controllers for continuous chemical processes incorporate three modes of control, or responses to any deviation of the process variable from the desired set point. These three responses are proportional, reset (or integral), and rate (or derivative).

Proportional response provides a corrective valve action *exactly proportional* to the deviation from the control point; reset *repeats* the proportional response at a predetermined rate until the deviation is eliminated; rate response provides a corrective valve movement proportional to the *rate* at which the measured variable is changing.

Optimum control is obtained when all three controller responses are adjusted to highest values permissible (thus producing greatest corrective valve action) within the limits of system stability.

Effect of Frequency on Each Mode

Analysis of the three controller responses shows that proportional response is flat (independent of frequency) and produces no phase shift.

Rate response contributes no gain (additional corrective valve action) at low frequencies; however, it starts operating at some preadjusted frequency and at higher frequencies it increases at an approximate rate of 12 decibels per decade (that is, the output signal increases 4 times for every tenfold change in frequency).

The maximum gain due to rate (corrective valve action due to rate action alone) generally is limited to 20 db (factor of ten to one), and attenuates in the third decade to exclude noise and transient effects (that is, the rate signals falls off at frequencies greater than 100 times the lowest frequency at which the rate signal begins to occur). Inasmuch as rate response depends on the rate of change of the signal, the corrective rate signal occurs ahead of the deviation itself—that is, a phase lead occurs. This phase lead can be as much as 56 degrees, depending on the controller design. When rate response is adjusted properly it produces a maximum phase lead at the resonant frequency of the control loop.

Reset response is proportional to the duration of the deviation. Therefore, its gain (corrective valve action) is zero at high frequencies because the duration of a high-frequency signal is extremely short. Going down the frequency spectrum, it starts operating at some preadjusted frequency and then increases at a rate of 20 db per dec-

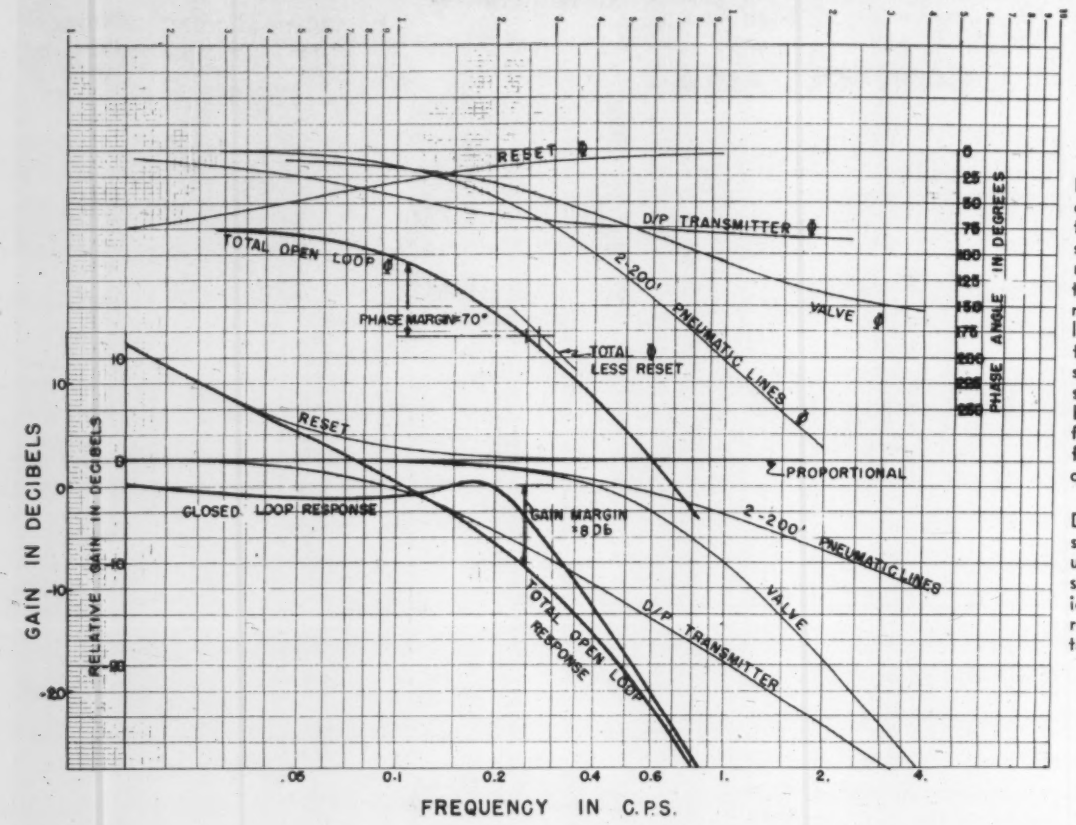


Fig. 2. Response of each element, and total system response, of a pneumatic system with two 200-ft. pneumatic lines. Controller shown has proportional plus reset response. Process response is not shown because it is a fast flow process with flat response at frequencies plotted.

Note: valve and D/P transmitter responses were measured; controller responses are theoretical; pneumatic-line response was obtained from Ref. 4.

ade (that is, the reset signal increases 10 times for every tenfold decrease in frequency). The *phase shift* introduced by reset is opposite to that of rate—that is, the phase shift due to reset is a *lag*. The maximum phase shift is 90 degrees, which occurs only at near-zero frequency. However, the reset is adjusted so that its phase shift is so small at the natural frequency of the control loop that it has little effect on the stability of the system.

Phase and Stability

For stability, the open-loop gain should not exceed unity at the frequency where the total phase lag is 135 degrees. If there were no phase shifts in the system there would be no stability problem.

Many of the time constants producing the phase shifts in the process are beyond the control of the instrument engineer. However, those in the transmitter, controller, transmission lines, and valve can be analyzed and minimized by the engineer. Use of electric transmission eliminates the two lags in the transmission lines (to and from the controller). The dead time inherent in pneumatic transmission also is eliminated. The resulting improvement in the frequency response of the system is more significant than may be realized at first. This improvement can be illustrated by a frequency-response analysis of the complete system.

Bode Diagrams

System performance is shown by use of frequency-response curves, or Bode diagrams [1,2]. This method of analysis is becoming standard for expressing both process and instrument performance[3]. The first step is the plotting of the open-loop gain and phase change of each element in the system.

In Figs. 2, 3, and 4 the gain of each element in a control system is plotted against frequency. Figs. 2 and 3 are pneumatic control systems; Fig. 4 is an electronic system. The curves show the individual effect of the three controller responses, the transmitter, the lines, and the valve. Adding the individual responses gives the total open-loop response shown.

Each Bode diagram represents an identical control problem with different types of control applied. The process under control is assumed to be a fast flow with a response that does not change until above 4 cycles per second. As this is much faster than the response of the valve and d/p transmitter, its effect on the total response is negligible. Hence the process response is not shown in Figs. 2, 3, and 4.

The gains of each element in the system are shown on these curves. In order to facilitate the combining of these gains in series, which normally would require the multiplication of each gain by all the others, the gains are shown in decibels. This permits adding of the individual gains because the decibel is a logarithmic (exponential) expression: Gain in db $= 20 \log_{10}$ (AR), where AR is the amplitude ratio, or the ratio of the output to the input amplitude. As adding exponents is equivalent to multiplication, the total gain of elements in series is found by adding their individual gains expressed in db's.

Both gain and phase shift are plotted against a common frequency scale. This is convenient as their interrelationship determines the performance which may be expected from a system. The total open-loop phase change may be determined by algebraic summation of the various component curves because phase changes are additive.

The following table will assist in converting from db to amplitude ratio:

Table for Converting db to Amplitude Ratio

db	−20	−15	−10	−5	0	5	10	15	20
ratio	0.1/1	0.18/1	0.32/1	0.56/1	1/1	1.8/1	2.3/1	5.6/1	10/1

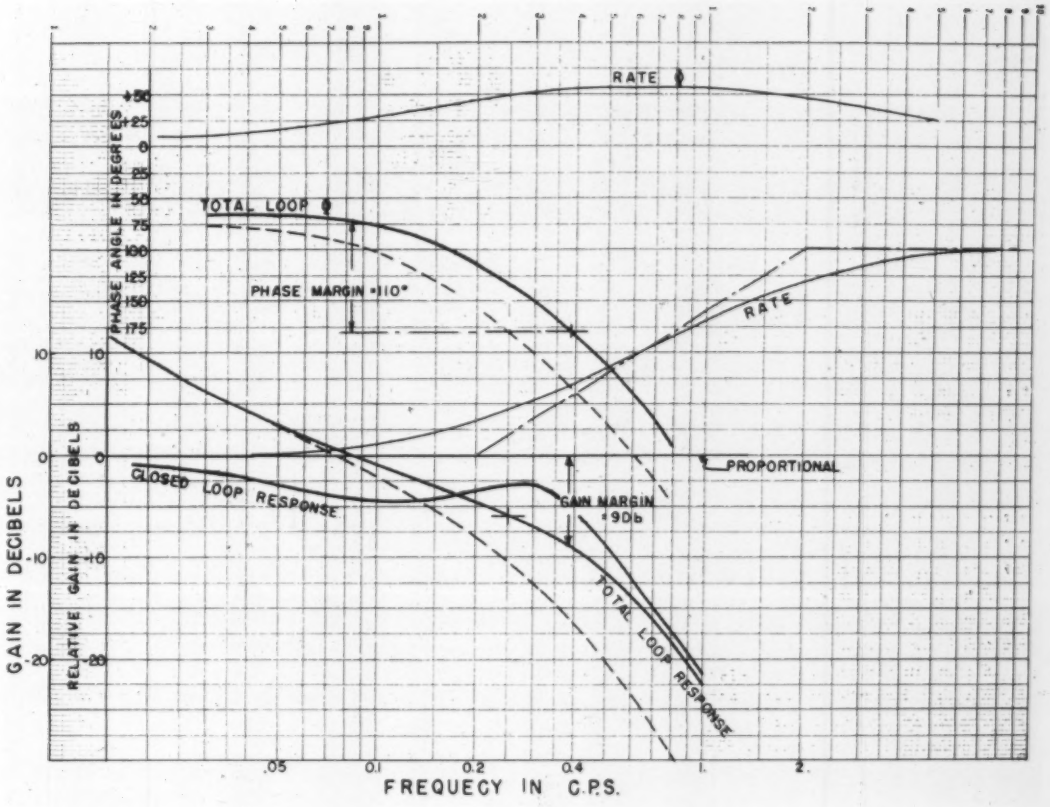


Fig. 3. Same as Fig. 2 with rate response added. Dotted lines just below "Total Loop Response" and "Total Loop Phase" are same as "Total Open Loop Response" and "Total Open Loop Phase" in Fig. 2, showing advantage of adding rate response.

Note that 6db is approximately 2/1; 10 db is about 3/1; 14 db is about 5/1; 20 db is 10/1.

Up to this point we have been considering only "open-loop" response (with the input to the transmitter independent of the process variable and artificially oscillated in a sinusoidal manner over the frequency range shown on the Bode diagram).

Closed-loop Response

This brings us to the "closed-loop response" as described by the effect on the process variable under artificial oscillation of the set-point adjustment at various frequencies.

Although the closed-loop-response curve has great significance in gunfire control and other servo applications where the set point is continuously varied, it is less significant in industrial control applications where the set point is usually stationary. The exception to this is found in cascaded control systems where the set point of a slave-control system is continuously varied by a master-control system. In any event, it is necessary to determine this curve because it is used to plot a very significant curve—"Response of Process to Load Changes" (Fig. 5). To plot the closed-loop curve, the points on the open-loop curve are referenced to the "Nichols Chart"[2] and replotted against the frequency scale. The "Nichols Chart" is a family of curves which provide for conversion from open-loop to closed-loop response.

For clarity, a departure is made from the conventional Bode diagram. Two gain scales are shown. The individual response of each element is first plotted against the "Relative Gain" scale, with the proportional response plotted with a gain of one (100-percent proportional band), or 0 db. The sum of the individual responses is then the total open-loop gain and total phase shift. Inasmuch as the gain can be as high as unity when the phase shift is 135 degrees, it is possible to increase the gain when it is less than unity. For example, in Fig. 4, the open-loop gain is minus 8.5 db at 135-degree phase shift. Shifting the db scale downward by 8.5 db is equivalent to increasing the proportional response (and hence the total open-loop gain) by 8.5 db. The closed-loop response is now plotted against this new scale, marked "Gain."

Note in Fig. 4 that the gain margin (open-loop gain) is minus 21.5 db (against the outer scale) at the point where the phase shift is 180 degrees—even after the 8.5-db increase in loop gain. As this is much greater than the minus 8-db gain margin recommended, the system is completely stable.

The pneumatic system in Fig. 2 reveals that the "gain margin" is the criterion of stability, rather than the "phase margin." This is caused by the rapid increase in phase lag produced by the pneumatic transmission lines. At the frequency where the open-loop phase curve passes through 180 degrees, the open-loop gain is shown to be minus 10.5 db (with a proportional gain of one). It is, therefore, possible to increase the controller gain by 2.5 db in order to establish a gain margin of 8 db. This is effected, as before, by shifting the db scale.

First-order and Second-order Elements

It is convenient to classify the response of various elements because many are basically similar. The simplest frequency-sensitive element is a simple resistance-capacitance unit, such as a resistor and capacitor in series, a restriction and volume in series, etc. These simple *first-order systems* are characterized by an attenuation rate of 20 db per decade (tenfold change in amplitude for tenfold change in frequency) above the cutoff frequency (the frequency at which the attenuation is 3 db and the phase lag is 45 degrees); also by a maximum phase shift that approaches 90 degrees.

A *second-order element* is essentially two first-order elements in series. Second-order elements are character-

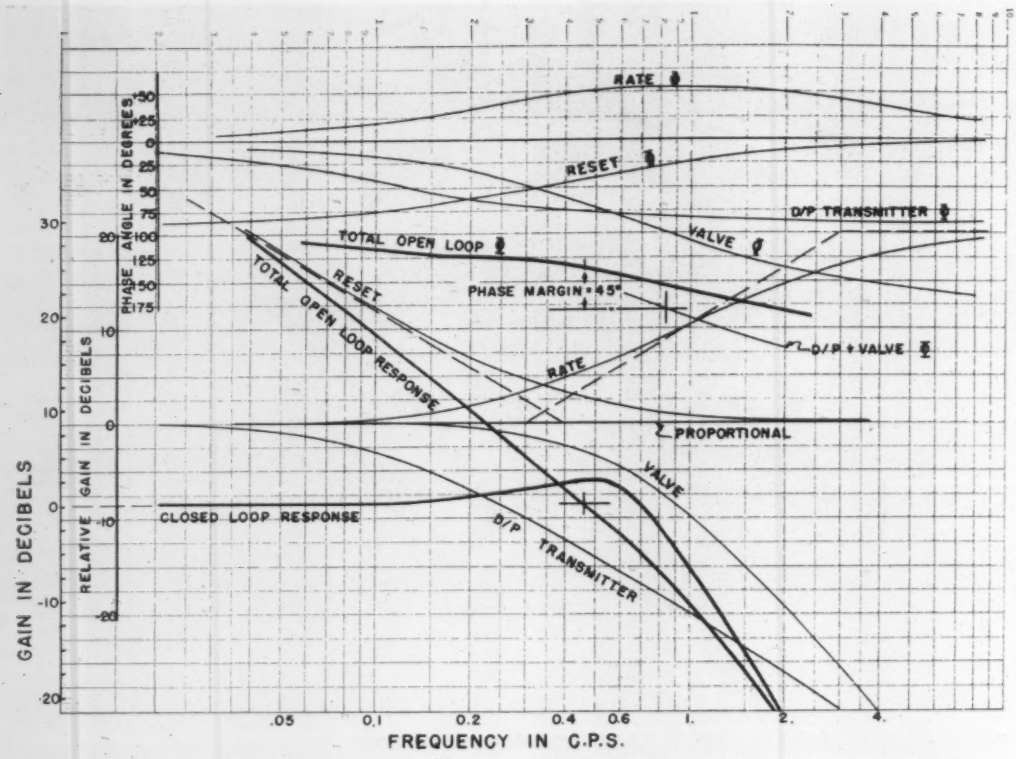


Fig. 4. Same process under electronic control with proportional, rate, and reset. Asymptotes in Fig. 3 and Fig. 4 are drawn to assist in obtaining the actual response curves.

ized by attenuation rates of 40 db per decade (hundredfold change in amplitude for tenfold change in frequency) and a maximum phase shift that approaches 180 degrees.

The valve used in the tests is a conventional diaphragm-motor valve with a topwork volume of 65 cubic inches. Its response is such that it can be described as a second-order system incorporating two identical time-constants of 0.23 second (determined by response to step change of 25%).

The differential-pressure (d/p) transmitter shown may be described as an overdamped 2nd-order system. In fact, the damping in this instrument is so high that it may be considered as a first-order system because the 2nd-order effects occur well above 10 cps.

For those unfamiliar with the Bode diagram as applied to process control, these notes may prove helpful: The position of rate and reset actions on the diagram are determined by the settings on the adjustments of the controller. Increasing the rate time in minutes moves the rate-response curve to the left. Increasing the reset response in "repeats per minute" moves the reset-response curve to the right. The asymptotes of these curves are shown as broken lines in Fig. 4.

Cutoff Frequency

The starting point of these asymptotes at the zero-db level represents the "cutoff frequency" or "break" point of each. These points may be determined for any given controller setting by the following formulas:

$$\text{(Rate)}\quad f_c = 0.00267/\text{Rate time in min.}$$

$$\text{(Reset)}\quad f_c = \text{Repeats per minute}/375$$

The formulas are derived from the basic formula:

$$f_c = 1/(2\,\pi\,T_c) = 0.16/T_c$$

Plotting the response curves is facilitated by first drawing the asymptotes—one with a zero-db-per-decade slope and the other with a 20-db-per-decade slope intersecting the first at the cutoff frequency. The actual response curves will approach these lines asymptotically and will pass through the 3-db point at the cutoff frequency. This is shown in Fig. 4 by the reset response.

The related phase-angle curves may be drawn by passing them through 45 degrees at the cutoff frequency, 25 degrees at $f_c/2$, 65 deg. at $2f_c$, and 85 deg. at $10f_c$.

Second-order systems should be plotted according to their first-order components. The asymptotes of the higher-frequency component will be a 40-db-per-decade slope, intersecting the 20-db-per-decade slope of the other component at the higher cutoff frequency.

In the pneumatic systems (Figs. 2 and 3) two 200-foot pneumatic lines have been used. This is common in industrial applications and precise data concerning their behavior is available[4]. Although it is possible to install pneumatic controllers locally in the process area, thus reducing the length of signal lines, it is not generally practiced. However, some instrument engineers insist on local installation of controllers on fast processes such as flow[5].

Although local mounting provides considerable improvement in frequency response, there are certain disadvantages which probably account for the lack of general adoption. One concerns subjecting the controller to the environmentals of the process area—corrosive atmospheres, vibration, shock, and varying ambient temperatures. Cost is another consideration because local installation necessitates use of four air lines instead of two. An additional disadvantage is that the controller adjustments are inaccessible to the operator. Granting the controversial aspects of these reasons it nevertheless can be shown that two lines, of only 40-feet each, limit the useable controller gain by a factor of 3 at high frequencies, and 6 at low frequencies, on a flow-control problem of the type under consideration.

Comparison of Results

Fig. 2 shows a conventional pneumatic system applied to the flow-control problem. Note that rate response is not shown as it is rarely used in this application. Fig. 3 shows the same system with rate response included. It is doubtful whether much benefit has been gained through use of rate. The fundamental problem is the rapid falling

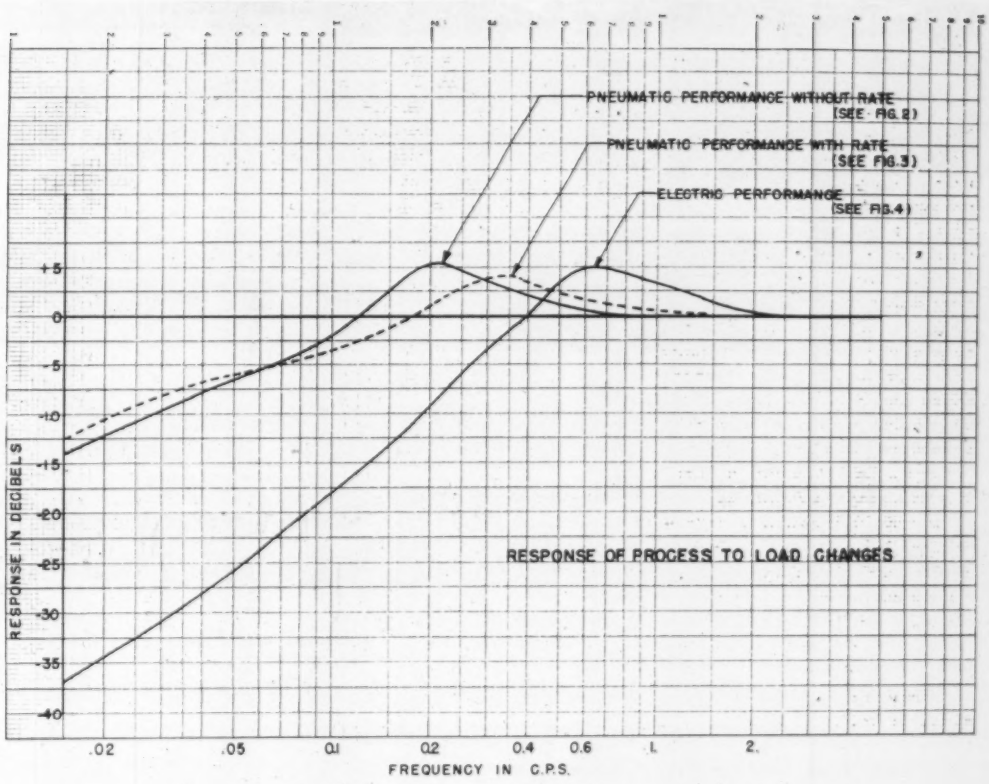


Fig. 5. Response of process to load changes.

off of the phase curve. While rate action alleviates this somewhat, the added gain reduces the "gain margin," resulting in a reduction of the proportional gain which can be used.

Fig. 4 shows the same system with electronic control applied. The rate response has been set at 0.009 minute; the reset response at 150 repeats per minute. The position of these curves reveals that a high degree of control gain is provided by all three responses. Considerably faster reset rate is used than earlier work had shown practical. This is evident from the overlap of the reset and rate asymptotes.

The higher gain is made possible because of the improvement in the over-all phase picture—which permits the additional phase shift created by the reset response.

Control Setting and Ultimate Period

The settings shown were determined by formulas which have been developed experimentally through analog simulation of a large number of different control problems. These formulas operate on the "ultimate period" (P_u) of the process, in minutes. This may be determined quickly in the field by turning off the reset and rate responses on the controller and increasing the proportional gain until a small constant-amplitude cycle is produced. P_u is then the duration of one cycle in minutes.

Working from the Bode diagram, $P_u = 1/(60\ f_r)$, where f_r is the resonant frequency determined by the intersection of the total process phase curve (less reset and rate effect) with 180 deg. The rate and reset formulas for setting the controller are:

$$\text{Rate (in minutes)} = 0.45\ P_u$$
$$\text{Reset (in repeats/min.)} = 2.95\ P_u$$

The above formulas have been specifically developed for use with the American-Microsen Control Equipment; applicability to other systems has not been investigated.

Response to Load Change

The curves shown in Fig. 5 have been developed from the Bode diagrams (Fig. 2, 3, and 4). These are determined by (1) plotting the reciprocal of the open-loop-response curves and (2) algebraically adding these new curves and the closed-loop-response curves to produce the "response of process to load change" curves.

Note that in addition to the improved high-frequency response, a large improvement is evident in the low-frequency response. At 0.01 cps the pneumatic system attenuates by a factor of 5 (14 db) whereas the electronic system attenuates by a factor of 70 (37 db). Use of a faster d/p transmitter or a faster electro-hydraulic valve operator would extend the frequency response further, the practical limitations being the presence of noise.

These curves illustrate clearly the improvement in control that can be achieved both at high and low frequencies by use of electronic technique.

Electronic Control System

The system to be described has been specially designed to utilize "direct-current" signals. This choice was made in preference to other types of signals, some of which are time-impulse, frequency, a-c. voltage, and d-c. voltage. The reasons behind the selection of direct-current signals are as follows:

1. It is easily converted to force for "force-balance" operation.
2. It is not affected by a-c. induced currents. This permits use of unshielded multiconductor cable, reducing cost and complexity of communication lines.
3. It is singly dimensional and problems concerning frequency and phase are eliminated.
4. It is simple to handle in cascade and ratio-control applications. Algebraic summation is simple.
5. It is compatible with input requirements of equip-

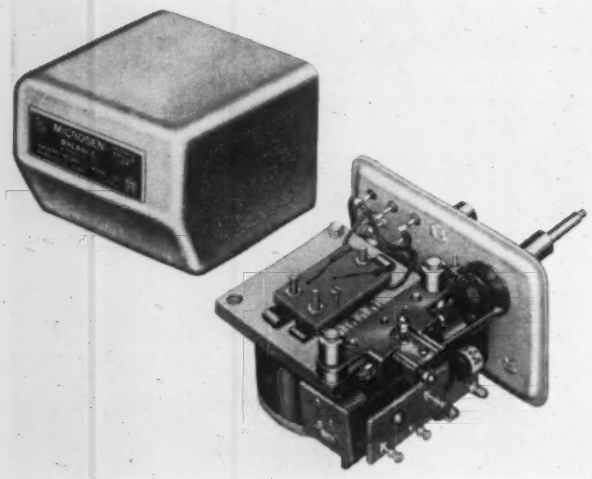


Fig. 6. "Microsen" balance.

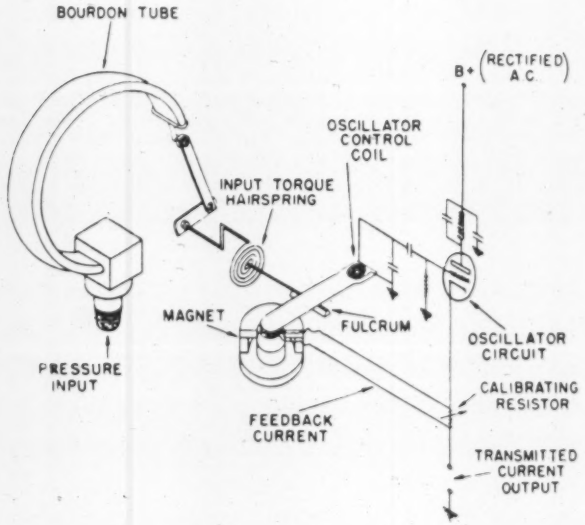


Fig. 7. "Microsen" balance used as pressure transmitter.

ment for high-speed monitoring, data-handling, print-out, and computation.

6. It is adaptable to self-regulation. As used, line and receiver resistance may vary between 1 and 3000 ohms without affecting current level.

7. The circuitry is simple and requires little maintenance equipment and technical know-how.

The Electro-Mechanical Balance

The key to the use of direct-current signals is the Electro-Mechanical Balance (Fig. 6). This device provides a means of comparing deflection with current level, and incorporates an error detector to sense any unbalance between the two values.

Fig. 7 shows the device coupled to a Bourdon pressure tube. The error detector is a small pancake oscillator-coil which operates in the grid circuit of a tuned-plate tuned-grid oscillator tube. Detuning of the grid circuit causes the tube to draw increasing current. Mechanical motion is introduced to the Electro-Mechanical Balance by a shaft coupled to the pivoted beam by a spring which converts motion to force. A coil suspended in a magnetic field is attached to the beam. The current in this coil produces a force in opposition to the mechanical force. (The analogy to pneumatic techniques is implicit when a bellows is substituted for the coil in the magnetic field, and an air-bleed nozzle is substituted for the oscillator coil.) The oscillator coil has complete control of the output level; no further amplification is required.

The standard output signal range is 0.5 to 5.0 milliamperes; this is produced by a beam deflection of 5 one-thousandths (0.005) inch.

As most process variables are measured by mechanical means, the Balance is directly adaptable. Some of the instruments available include the Mason-Neilan and Fisher-Governor displacement- and ball-float-type liquid-level elements, the Barton differential-pressure cell, and the Hagan Ring-Balance flowmeter. Temperature transmitters are available with both mechanical and thermocouple inputs. Pressure elements are, of course, Ashcroft.

In addition to its application in transducing measurements, the Electro-Mechanical Balance is employed in the set-point unit (or deviation detector) and in the recorder. In the recorder (Fig. 8) the input to the Balance is direct current and the feedback is the mechanical force created by the position of the pen. Any unbalance between these forces is instantly detected by the oscillator coil, which produces corrective signals to a powerful rotary solenoid which positions the pen. Selective damping is provided by a switch.

The Balance in the set-point unit (Fig. 9) compares the input current to a mechanical force determined by the position of the set-point adjustment. Unbalance of these forces is detected by the oscillator coil, and a current is produced which is fed through a second coil in the magnetic field to re-establish equilibrium. The magnitude and polarity of the current flow in the feedback circuit is converted to voltage; this is the error signal fed to the controller. The set-point unit is completely independent of the recorder and is, therefore, not limited by the frequency response of the latter.

Electronic Controller

The Controller (Fig. 10) consists essentially of two high-gain amplifiers with resistance-capacitance networks in their feedback circuits to provide accurate and reliable time-constants for integrating and differentiating actions. Rate and reset adjustments select the resistance value in these circuits.

The arrangement of the control responses follows the Clarridge[6] approach, and differs from the conventional controller in that the rate response precedes the proportional and reset responses. The rate section is preceded by a proportional response with a fixed gain of 0.5 (200-percent proportional band). This produces a marked improvement in start-up performance because rate action is available regardless of the magnitude of the deviation or narrowness of the adjustable proportional band.

Another feature of the controller is the operation of the "Manual" to "Automatic" transfer. The Manual Positioning Station consists of a small separate unit, usually mounted directly in place on the graphic panel. When on "Manual" control, the M/P Station provides an independent source of regulated current to the valve. The controller remains functioning even though its output is short circuited. However, the output of the M/P Station is referenced to the flow of current in the controller circuit, which follows it precisely because any difference between the two current levels appears as a corrective voltage in the reset circuit of the controller. This eliminates the balancing procedure usually required in order to prevent "bumping" the valve in transfer. The operator has

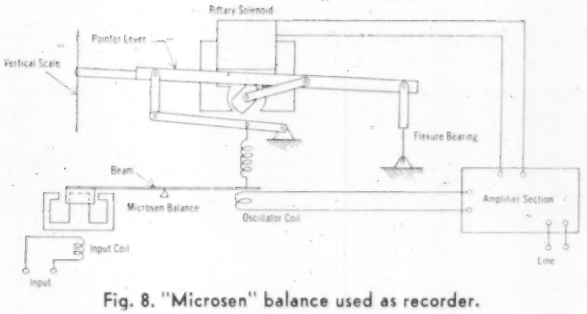


Fig. 8. "Microsen" balance used as recorder.

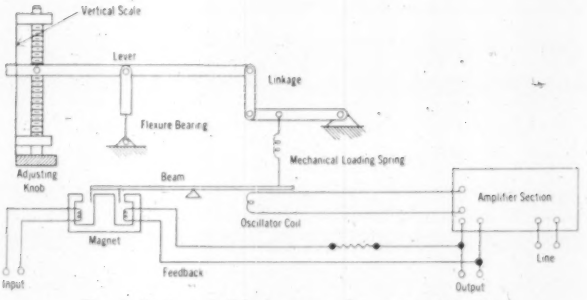


Fig. 9. "Microsen" balance used as set-point unit.

only to push the "Auto" button when he desires to relinquish hand control.

The valve positioner (Fig. 11) receives the standard current signal of 0.5 to 5.0 milliamperes. it is similar to the pneumatic type. A conventional flapper and nozzle are incorporated. The position of the valve stem is converted to force by a spring coupled to the flapper; this is compared to the current force produced by the coil which is directly connected to the flapper. The air-bleed nozzle detects the unbalance and controls the air to the diaphragm operator.

Data Handling

Rapid progress has been made in the techniques of handling data automatically. Most analog-to-digital converters and print-out devices read d-c. voltage signals

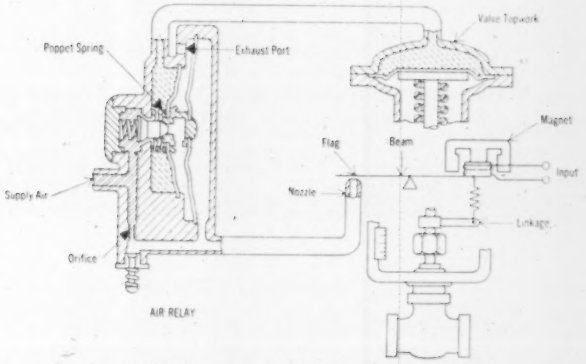


Fig. 11. Electro-pneumatic converter for valve.

and are, therefore, directly compatible with the direct-current signals. The economic implications are important as process log sheets are often tabulated by the operator on an hourly basis. The equipment necessary to automatically type these data at prescribed intervals, on master log sheets, may be purchased for the cost of one-half a man year for an average-size process unit. In addition to tabulation, other functions are available which include automatic integration and continuous scanning for alarm points. These features add to the versatility of electronic instrumentation.

Acknowledgment

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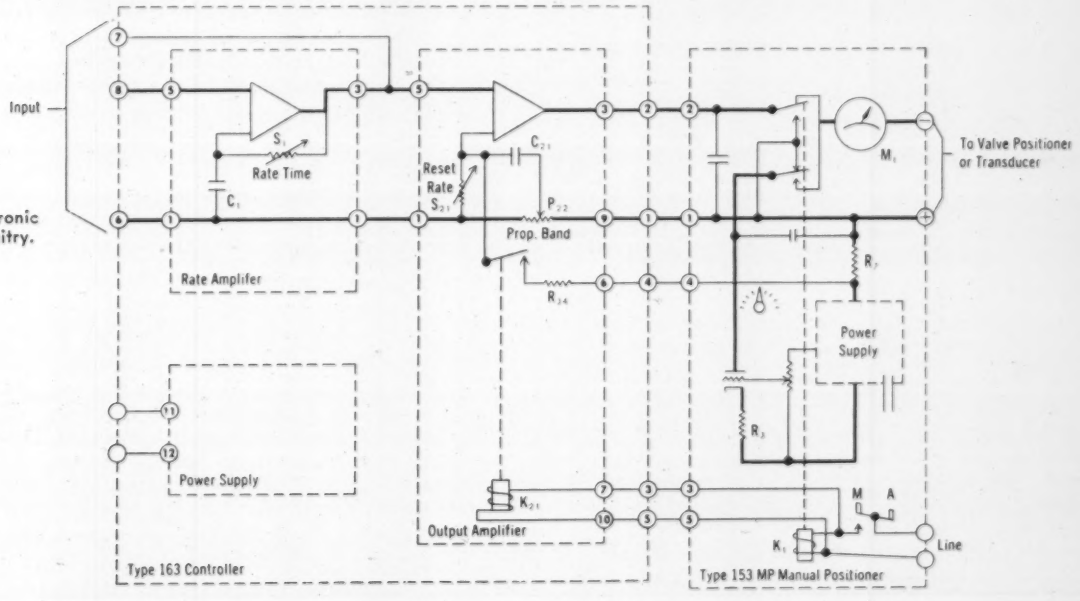


Fig. 10. Electronic controller circuitry.

BLAST-FURNACE

A. W. ROBINSON
John Mohr & Sons

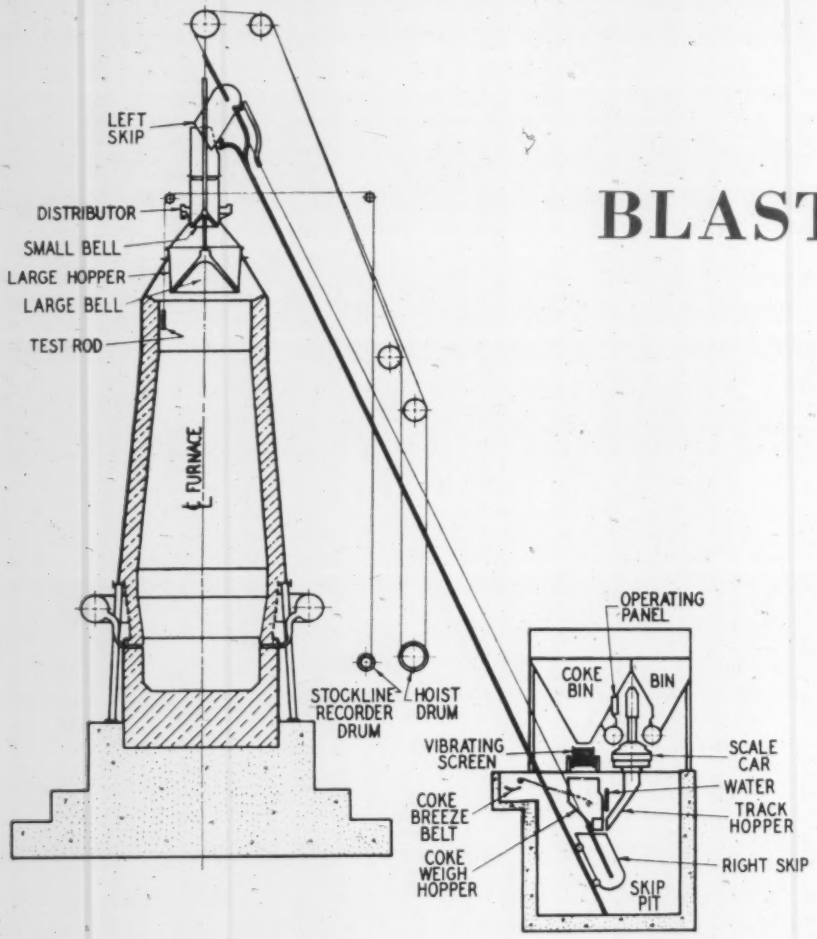


Fig. 1. Blast furnace and charging equipment.

AUTOMATIC CONTROL is applied to the operation of blast furnaces to increase the productive capacity, to decrease the off-grade product, to lower manpower requirements, to reduce possibility of human error, and to protect an investment up to $10,000,000.

The basic feature of the Mohr automatic control system is interlocked control of every phase of the furnace-charging program. The system also controls the temperatures of the hot-blast stoves and of the blast itself.

The system described was coordinated and installed in blast furnaces at (1) Dominion Foundries & Steel Limited, Hamilton, Ontario, Canada, (2) Crucible Steel Company of America, Midland, Pa., and (3) Detroit Steel Corporation, Portsmouth, Ohio. Contributing to the program and furnishing equipment for the system were Steel Mill Engineers, General Electric Company, Canadian General Electric Co. Ltd., Leeds & Northrup Company, and Askania Regulator Co.

Charging Program Control

The charging system (Fig. 1) is based on a system of interlocks so that the charging sequence can proceed only in a preset manner. The system comprises:

1. A scale car which runs on a track underneath the iron ore, scrap, slag, and limestone storage bins, and into which is charged a predetermined weight of ore or limestone as called for in the furnace burden calculation. The scale car consists essentially of two hoppers which are filled independently to a weight desired by the scale-car operator. After the hoppers are filled the scale car is moved on the track to a position over the *skip cars*, and the previously weighed amounts of materials are discharged from the scale car into one of the two skip cars.

2. On either side of and above the skip-car pit are two central *coke bins*. Under these bins are two separate vibrating screens which discharge their coarse product into coke weigh hoppers, and their fine product onto a belt which transports these materials away from the furnace to a distributing point for coke breeze. The coke weigh hoppers are provided with automatic gates and can charge the skip cars with a predetermined weight of coke.

3. Means for transporting the raw materials to the top of the furnace is provided by the two skip cars, which operate on parallel inclined tracks. As one car ascends to the top of the furnace the other descends to the pit.

4. At the top of the furnace the skip load is dropped into a revolving hopper, or distributor, which permits charging the materials at different positions around the furnace so that an even distribution is maintained.

5. The bottom of the revolving hopper is equipped with a gate known as a *small bell*. After the hopper has revolved, the small bell is opened and the load falls into a large hopper, which also has a gate on the bottom.

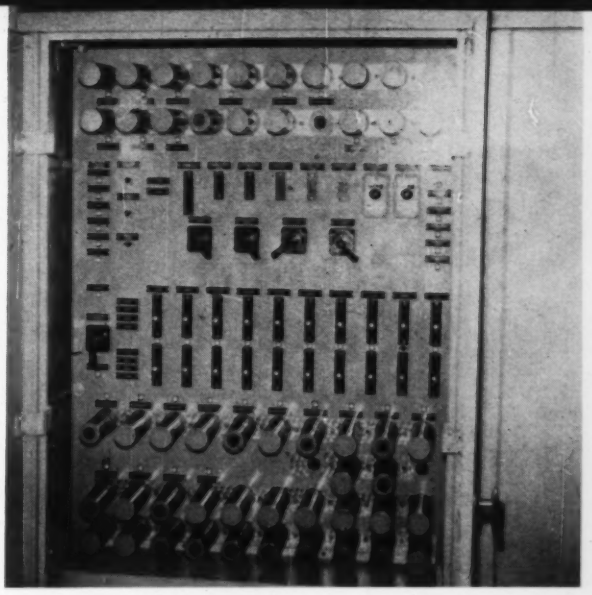
6. This gate is known as the *large bell*. After a prescribed number of skip loads from the small bell are emptied onto the large bell the large bell is opened and the material falls into the furnace. The purpose of the two-bell system is to prevent the loss of the products of combustion from the furnace to the atmosphere because they not only are toxic but also are used for heating the checkerwork of the hot-blast stoves, and for firing coke ovens, soaking pits, and steam boilers.

7. Another component of the charging system is a

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, March 25, 1954.

AUTOMATION

Newest feature in automatic control of modern blast furnaces is control of the entire charging program. Recording of top temperature, downcomer temperature, stockline level, stockline speed, and inwall temperatures are basic guides for the operator. New techniques also include automatic control of hot blast at each tuyere, and continuous analysis of furnace gas.



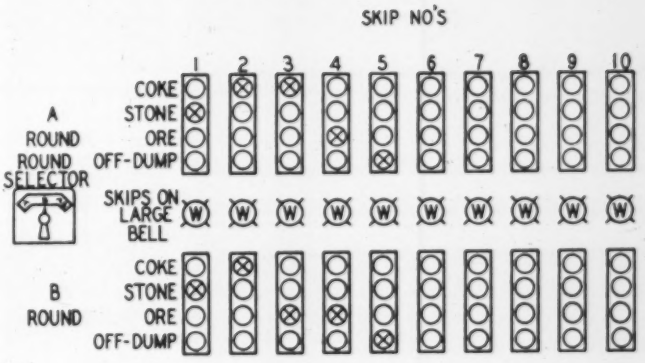


Fig. 2 (top). Half of main control panel for furnace charging control.

Fig. 3. Selector buttons on main control panel, showing round-selection switch and skip-control buttons (center area of panel in Fig. 2).

stockline test rod, of which usually two or three are supplied with each furnace. These test rods indicate to the operator the distance of the burden or stock below the large bell, telling him when the furnace needs to be charged and also warning him if the burden is not descending properly in the furnace. In order to prevent damage of these rods it is necessary that they be removed from the stockline each time the large bell is lowered.

8. Also included with the charging system is a *stock watering device* which delivers a predetermined amount of water to a skip car. This water decreases the amount of dust produced by the furnace and lowers the top temperature so that the steel work at the top of the furnace is not overheated from high furnace-gas temperature.

The Mohr Program Control automatically initiates these various operations in the proper sequence in addition to checking circuits to insure that the proper conditions exist before moving to the next operation. All functions can be either automatic or manual, as selected by the operator. A detailed description of the control is given in a General Electric publication by J. E. Oram[1] and by C. P. Hamilton[2] of the same company.

The control system includes rotary stepping switches, latch-in relays, control relays, transfer switches, and push buttons combined to give a prescribed operation sequence (Fig. 2). A spare relay of each type, provided in the main control panels, can be substituted quickly into a circuit while the replaced relay is checked. The two main panels occupy a total space of 8 ft. x 3 ft.

Indicating lights on the operator's panel-board in the stockhouse give the operator the following information: (1) Position of stockline. (2) Degree of distributor rotation. (3) Condition of coke hoppers. (4) Position of large bell and small bell. (5) Position of skip cars. (6) Material required in the next charge to the skip car. (7) Which round of the program is being carried out and how many skips of this round have been dropped on the large bell.

Furnace Program

Assume that the furnace program consists of two rounds—A and B, and that A round and B round are to be charged alternately to provide the proper burden for the furnace. Assume that A round consists of one skip of stone, two skips of coke, and one skip of ore; and that B round consists of one skip of stone, one skip of coke, and two skips of ore. The round-selector switch on the main control panel (Fig. 3) is set on position "A B," which will automatically alternate rounds A and B. The stone button will be depressed on round A for the first skip, the coke button for skips two and three, the ore button for skip four and the off-dump button for skip five. On the round B the stone button will be depressed for skip one, the coke button for skip two, the ore buttons for skips three and and four, and the off-dump button for skip five.

Assuming that the control light indicates the left skip to be in the pit, the operator will then drop a load of stone from the scale car into the left skip. He presses the skip start button, and the left skip moves out of the pit and ascends to the top of the furnace, the right skip descending to the pit. As the next two skip tubs are to be filled with coke (an automatic operation) the scale car operator, who rides on the car, moves the car to the bins to fill the scale-car hoppers, filling the right skip with ore and the left with stone for this particular burden.

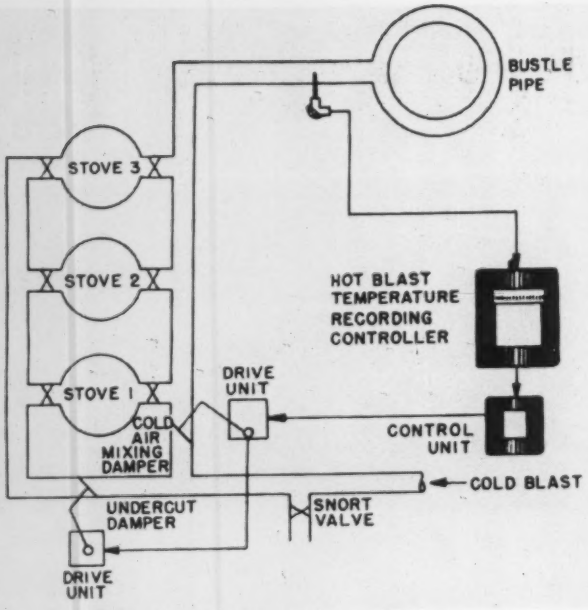


Fig. 4. Hot-blast temperature-control system.

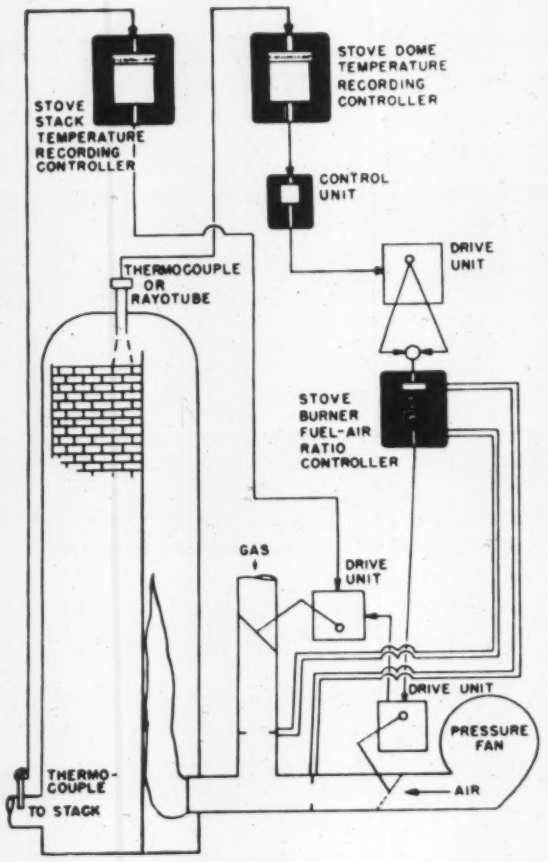


Fig. 5. Stove temperature-control system.

As the loaded skip nears the top of the furnace it automatically decelerates. If for any reason the small bell is open or the previous charge has not been dropped from the small bell, the skip will stop and wait for the small bell to complete its cycle and then will continue on the charging position.

As the right skip reaches the pit the right coke-hopper gate motor is energized to open the gate and drop the coke into the skip. When the hopper is empty the gate is closed and the skip automatically ascends the skip incline. As the right skip leaves the pit it causes the small bell to be lowered so that the charge from the first skip is dropped onto the large bell. When the small bell is closed the skip count light on the operator's panel will indicate that skip one has been charged to the large bell.

Meanwhile, the screen over the empty coke hopper has been started, filling the hopper with the desired weight of coke. When the left skip reaches the pit a pre-measured quantity of coke will be loaded into it. A light on the operator's panel shows that skip four is to be ore; as the right skip enters the pit the operator loads it with ore from the right scale car hopper and presses the start button. Since a light indicates that the next skip (the first one of round B) should be charged with stone, as the left skip enters the pit the operator loads it with stone from the left scale car hopper and presses the start button. As this skip leaves the pit the small bell is lowered, dropping the last skip load of round A to the large bell. The small bell closes and the large bell opens, charging the four skips of round A into the furnace. The sequence for round B is then continued in the same manner as round A: upon its completion the control is automatically changed back to round A again.

Interlocking features are provided with the program control so that certain operating procedures can go into effect only when a correct situation exists to carry out these procedures. For example: (1) Coke can only be discharged into its respective skip when this skip is in the pit. (2) The scale car hopper gates can be opened only when the scale car is centered over the pit, the program calls for an ore or stone charge, and the respective skip is in the pit. (3) The small bell must be closed before the large bell can open, and the large bell must be closed before the small bell can open. (4) The revolving hopper must be stationary while the skip is discharging, and the stockline recorder rods must be lifted to the top of the furnace before the large bell can open.

Stove Temperature Control

Each stove used to heat the air going to the furnace is supplied with a gas burner; burner combustion is controlled by a fuel-air ratio regulator. The stove temperature control (Fig. 5) consists of (1) the dome-temperature control and (2) the flue-temperature control, each of which can take over the control of the gas being delivered to the stove, depending on the temperature existing in that part of the stove.

The stove dome-temperature control insures that the dome will not become over-heated. If the dome temperature approaches the preset control point the dome-temperature recording controller adjusts the fuel-air ratio controller to introduce excess air to the burner, thus decreasing the temperature of the products of combustion in the stove.

If the fuel-air ratio regulator has moved through its entire range so that it can supply no further excess air to the burner, control is transferred from the drive unit on the fuel-air ratio controller to a drive unit operating a butterfly valve in the gas inlet to the burner. This drive unit closes the butterfly valve, reducing the amount of gas to burner.

A similar control point is established in the flue of the stove; as this temperature is approached the stack-temperature recording-controller closes the butterfly valve in the gas line. In this way automatic control of both dome temperature and flue temperature is maintained.

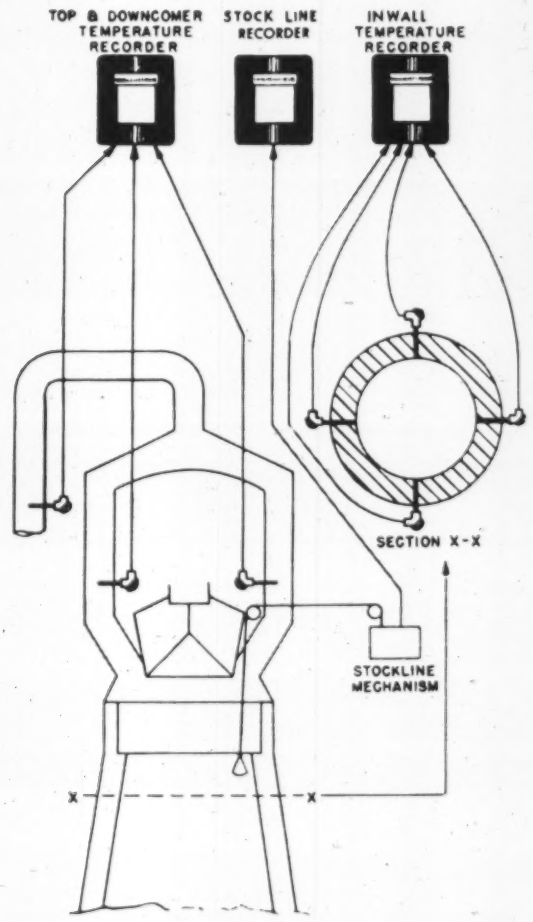


Fig. 6. Instrumentation for recording inwall temperature, gas temperature, and stockline level and speed.

Hot-blast Temperature Control

The air passing from the stove is considerably hotter immediately after the stove has been heated by the gas burner than it is after cold air has been introduced into the stove for a half hour or more. For this reason cold air is admitted to temper the hot air from the stove so that maintenance of a uniform blast temperature is possible (Fig. 4). At the beginning of the stove operation a maximum amount of tempering air is admitted; this amount is gradually decreased as the average temperature of the stove decreases until such time as the stove is unable to maintain the desired blast temperature without any mixing air. At this time that particular stove is shut off and air is passed through another stove.

A thermocouple is placed in the hot-blast main from the stoves near the circular bustle pipe at the furnace. Butterfly valves are placed in the cold-blast line (from the turbo blower) and in the mixer line which tempers the air at the stove outlets. A pre-set temperature is established by the hot-blast temperature recording-controller, which controls the butterfly valve in the mixer line. If this butterfly valve is wide open and the temperature of the hot blast is still above that of the control point, the control is transferred to the drive unit operating the butterfly valve in the cold-blast main from the turbo blower, closing this valve and forcing more air through the mixer line and less through the stoves. As a result hot-blast temperature can be maintained at a uniform level.

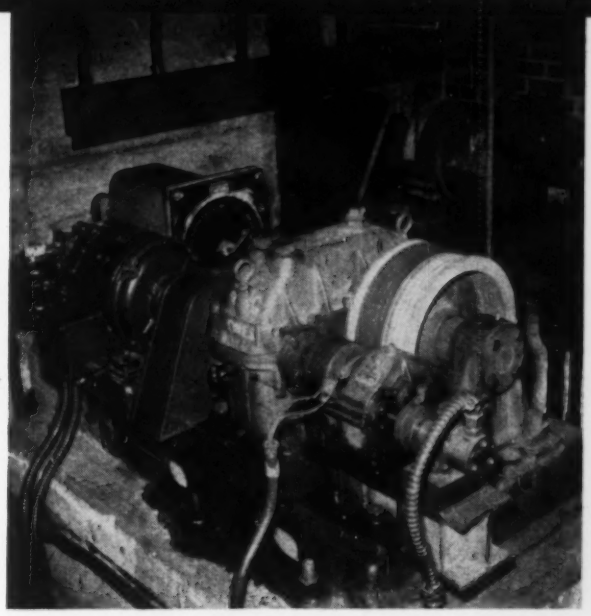


Fig. 7. Stockline mechanism for measuring position and speed of stockline.

Furnace-temperature and Stockline Recorders

Recording of the temperature at the top of the furnace, and of the level and the rate of descent of the stockline, is extremely important to the furnace operator. Furnace inwall thermocouples usually are installed near the top of the furnace at 90-degree intervals around the circumference (Fig. 6); they may be placed at one or more levels. Also, the temperature of the gases coming from the furnace is measured before and after cleaning.

The position of the stockline level, through an interval of 0 to 20 feet below the large bell, is measured by a slidewire on the shaft of the stockline winch. A tachometer generator on this winch generates a voltage proportional to the speed of the stockline descent so that the stockline speed also can be measured in units of 0 to 10 feet per minute. Both stockline level and speed are recorded continuously. A clutch is provided and the tachometer is declutched when the rod is withdrawn from the furnace (Fig. 7).

Future Development

While not yet considered as standard practice, there are several other automatic techniques which are in successful operation on blast furnaces in the United States and Europe. Foremost among these are:

1. Automatic handling and charging of limestone from central bins and weigh hoppers, in the same manner as the coke-handling described.
2. Automatic control of the volume of hot blast introduced at each individual port or tuyere of the furnace, of which there may be as many as twenty.
3. Continuous analysis of the furnace gases (which helps the operator to prevent production of off-grade iron), and continuous measurement of the dirt in the gases to check the efficiency of the gas-cleaning system.
4. Automatic reversal of air and gas valves on the hot-blast stoves, for rapid change from one stove to another.
5. Automatic control of the moisture in the hot blast to the furnace through continuous measurement and introduction of steam.

References

1. A General Electric Publication.
2. Hamilton, C. P., "Integrated Electrical System—Heart of the Modern Blast Furnace," *Steel*, Vol. 34, No. 8, February 22, 1954.

ELECTRONIC

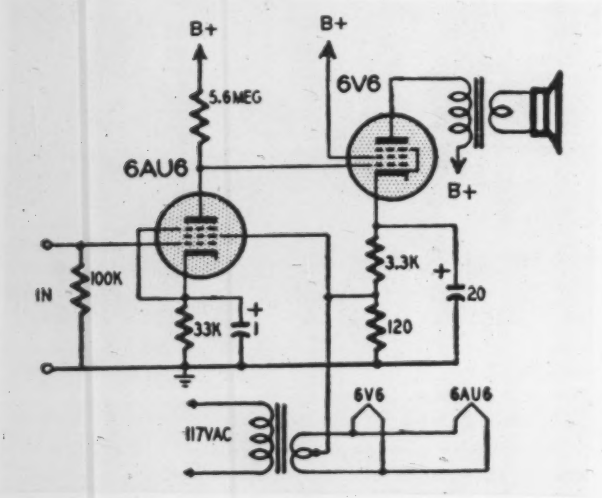
MILTON ARONSON
Instruments Publishing Co.

and

CHARLES KEEZER
Potter Instrument Co.

STARVED-CURRENT AMPLIFIER

Maximum gain of a conventional pentode is about 250. However, by "starving" the pentode (lowering screen voltage below 10 percent of plate voltage, and using plate load resistor of about 10 times the conventional value), the amplification factor is increased greatly. This "starved-current" pentode (6AU6) gives a gain of about 750 with load resistor of 5.6 megohms and screen voltage of about 2 volts.

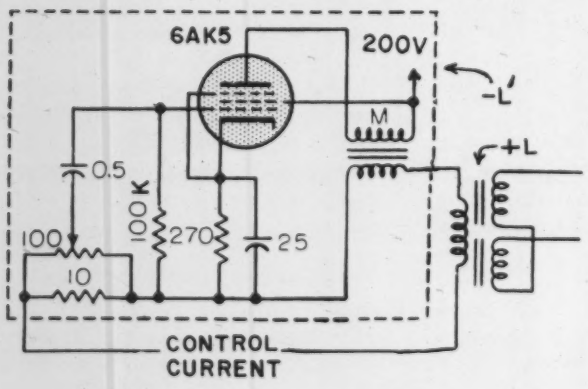


The starved-current pentode is shown direct-coupled to a 6V6 power amplifier for audio (a grid resistor would reduce gain). Only 2 millivolts input is required for 0.1 watt output (92-db gain). However, high-frequency response is poor because of tube and circuit capacitances shunting the 5.6-meg resistor (response is down 3 db at 180 and 2500 cps.) Heaters are biased 2 volts pos. to reduce hum.

B supply: 200 volts at 26 ma.
Gain of 6AU6: 750
Gain of audio amplifier: 92 db
Source: P. S. Lederer in *Radio-Electronics*, March, 1954.

NEGATIVE-INDUCTANCE CIRCUIT

In inductive circuits, the time constant of the circuit (L/R) limits the frequency response (bandwidth). The circuit shown is an effective negative inductance which, in series with a positive inductance, can cancel the time constant (or even reverse the phase so that the current *leads* the voltage). The circuit was developed to reduce the time constant of magnetic-amplifier circuits, but can be applied to any inductive device—relays, transducers, etc.



The current in the positive inductance (control current for a magnetic amplifier) causes voltage iR across the 10-ohm resistor. This causes plate voltage MGRdi/dt (where G is mutual conductance of tube; M is mutual inductance of transformer). Transformer is connected to give M a negative sign with respect to external circuit. Hence plate voltage is –MGR di/dt, which can be written –L′ di/dt. This is effectively a negative inductance in series with the external positive inductance. Adjustment of 100-ohm potentiometer varies plate-signal amplitude, which is effectively same as change in L′. Hence negative inductance can be varied to be less than, same as, or more than L. Complete cancellation of time constant of magnetic amplifier was effected by this circuit for signals up to 2000 cps.; DC stability of circuit was not affected.

Source: G. M. Ettinger in *Electronics*, Jan., 1954.

FLIP-FLOP WITH CLAMPED OUTPUT

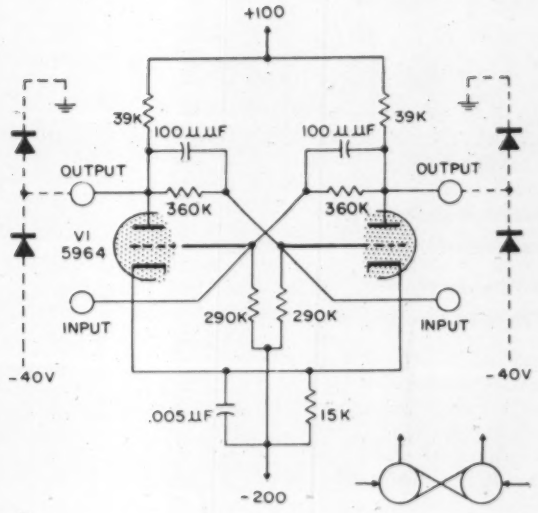
The flip-flop is a bistable multivibrator used for counting, frequency-division, binary scalers, etc. As grids are direct-coupled to opposing plates, there are two conditions of equilibrium—one tube conducting, other tube nonconducting. Negative 40-v. pulse (for counting rates up to 20 kc) or neg. 80-v pulse (for up to 100 kc) causes conducting tube to cut off, and other tube to conduct. Output signal would be greater than 100-v square or rectangular wave without clamping diodes shown. With clamp, output is 40-v square or rectangular wave. For binary counting, the two inputs would be connected together (through 10-uuf capacitors) so that tube would "flip" and then "flop" on successive pulses.

Clamping diodes prevent output from going above ground potential or less than minus 40 volts. Hence output is a square or rectangular wave that swings from ground to minus 40 volts. Rise time is less than 1 usec; decay time less than 4 usec; operates at rates up to 100 kc. Circuit is available as plug-in unit from supplier.

Uses: Binary or linear counting, frequency division,

CIRCUITRY

The circuit is the heart of all electronics. This begins a series on basic electronic circuits, the "tricks of the electronic trade." Unless marked, resistors are in ohms, capacitors in microfarads.



switching, driving logical "and" "or" circuits (with clamp).

Output: 40-v square or rectangular pulse (with clamp); over 100-v square or rectangular wave (without clamp).

Input: 40 to 80 v. neg. pulse or square wave.

Frequency range: 0 to 100 kc.

B supply: 100 v at 6.8 ma.;
200 v at 7.0 ma.
40 v at 4.4 ma. (for clamp)

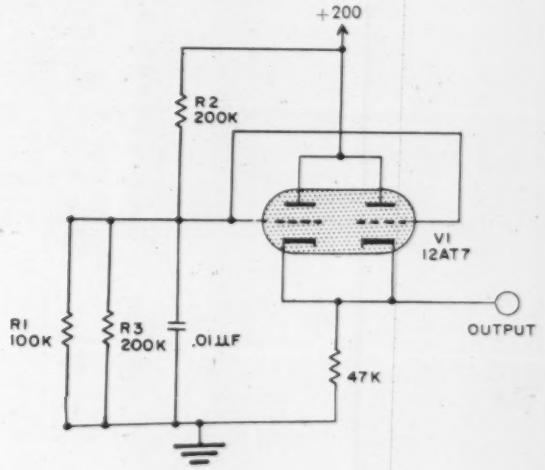
Source: EECO Production Co., 827 S. Vermont Ave., Los Angeles 5, Calif.

CATHODE-FOLLOWER REGULATOR

As a cathode follower has low output impedance, it can supply current to a load with fair regulation against load change. This circuit uses two high-mu triodes in parallel. Output voltage is established by grid potential, which is determined by voltage-divider network R1, R2, R3. As shown, grid potential is about 40 v; output voltage is about 50 v at 20 ma (full load). Regulation is 5 percent from no load to full load (20 ma); output changes 1 v for each 8-ma change in current.

Output voltage depends on voltage divider; other output voltages, including negative values, can be obtained by changing circuit constants and by use of positive-grounded power supply. For example, deleting R1 produces output of 100 v dc at load currents to 15 ma.

Output will follow all variations in supply voltage; hence supply voltage should be regulated—except where



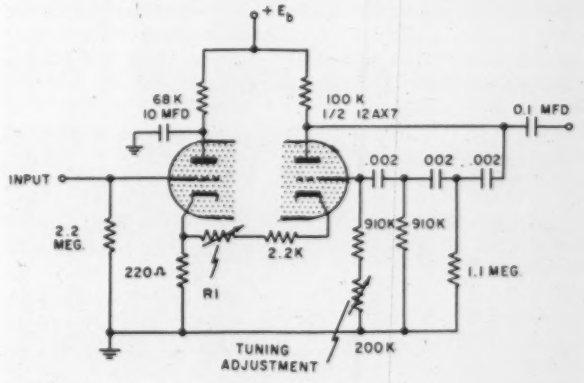
voltage division is desired. Note that circuit is a basic voltage divider with no loss of power (as in conventional bleeder-dividers). Circuit is available as plug-in unit from supplier.

B supply: 200 v dc, regulated; 1 ma no load, 21 ma full load.

Source: EECO Production Co., 827 S. Vermont Ave., Los Angeles, Calif.

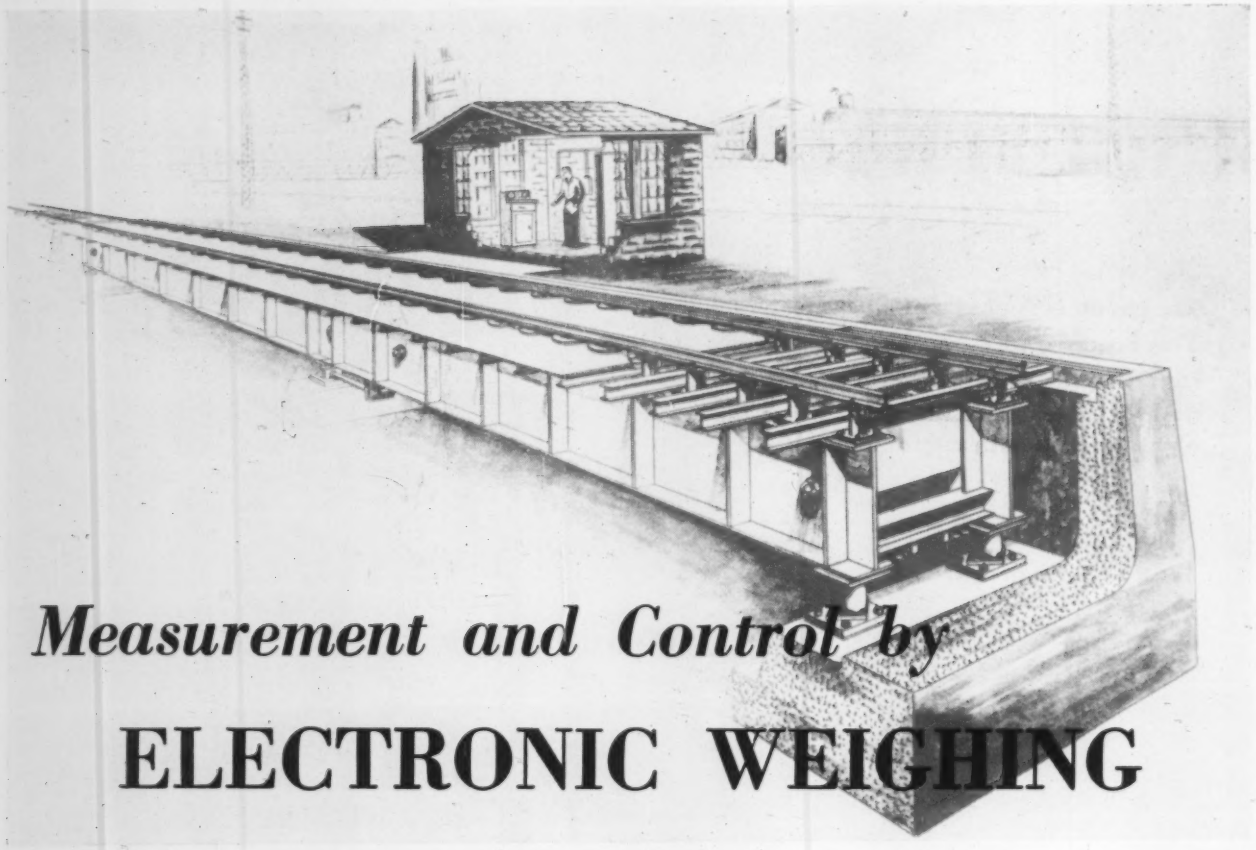
TUNED-AMPLIFIER FILTER

A phase-shift oscillator whose gain is reduced to below the oscillating point acts like a high-Q filter, or tuned amplifier. In the circuit shown, the left-hand stage (½ of a 12AU7) is a cathode follower that is cathode coupled (through the common 220-ohm cathode resistor) to the phase-shift oscillator. However, the oscillator (½ of a



12AX7) can not oscillate because it requires a gain of 28 for oscillation—and the gain is adjusted by the bias resistor R_1 (1000 ohms) to be less than 25. The circuit is thus highly regenerative at the tuned frequency (29.5 cps), but cannot become unstable. Thus the circuit is a high-Q filter (at 29.5 cps) without use of inductors. Small tuning changes can be made with the 200K potentiometer.

Source: Hansel in *IRE Proceedings*, Dec., 1953.



Measurement and Control by

ELECTRONIC WEIGHING

Electronic weighing techniques are finding ever-increasing uses. Typical basic elements for electronic weight determination, and how they are adapted to many weighing applications, are presented, as is an intriguing glimpse of planned developments.

VERNE C. KENNEDY
Streeter-Amet Company

ELECTRONIC SCALE comprises three basic elements—load cells, servo system, and data-presentation device. The weight to be measured is placed on the load cells, which produce an output voltage proportional to the applied weight. This voltage is fed to the servo system, which automatically adjusts a balancing potentiometer to an equivalent position and, at the same time, positions the data-presentation device.

Basic Scale Systems

Fig. 3 shows the basic electronic weighing systems. Load cells can be placed under a conventional weighbridge, in a crane scale with attached hook, or in various equipments in diverse ways. Cables convey the electrical weight information from the load cell to the instrument which contains the servo system and one or more data-presentation devices. When batching, regulation, intermittent feeding, and other automatic processes are involved, additional instrumentation is included in the weighing system.

Load Cell

The load cell (Figs. 2 and 4) consists of a calibrated steel loading column, four strain gages bonded to the sides of the column, and a hermetically sealed metal container. The four strain gages (fine resistance wire laid back and forth on a thin strip of impregnated paper) are connected electrically in the form of a Wheatstone bridge. Two diametrically opposite corners of the bridge are connected in series with the input terminals of the load cell; the other two corners serve as the output terminals.

During operation, a constant a-c. voltage is impressed across the input terminals of the cell. For no-load conditions, the bridge is in electrical balance and the output voltage is zero. When a load is placed on the steel loading column, the column deformation changes the resistance value of each gage, which unbalances the bridge and causes an output voltage proportional to the load.

Servo System

The servo system measures the load-cell output voltage by comparing it with a reference a-c. voltage. Major components of the servo system are (Fig. 5) a balance bridge, an amplifier, a two-directional servo motor, and a zero-adjust bridge. Note that the input to the amplifier consists of three voltages in series—load-cell voltage V, bridge voltage X-Y, and a portion of the zero-adjust voltage. With no load on the load cell, the system is at zero balance. However, if a load is placed on the cell, a voltage appears across the amplifier input terminals. The amplified voltage directs the servo balance motor which, through a mechanical gear system, drives both the rotary precision potentiometer in the balance bridge and the movable element of the data-presentation device. The

Contributed by the Instruments and Regulators Div. of The American Society of Mechanical Engineers at the Eighth National Instrument Conference, Chicago, Ill.

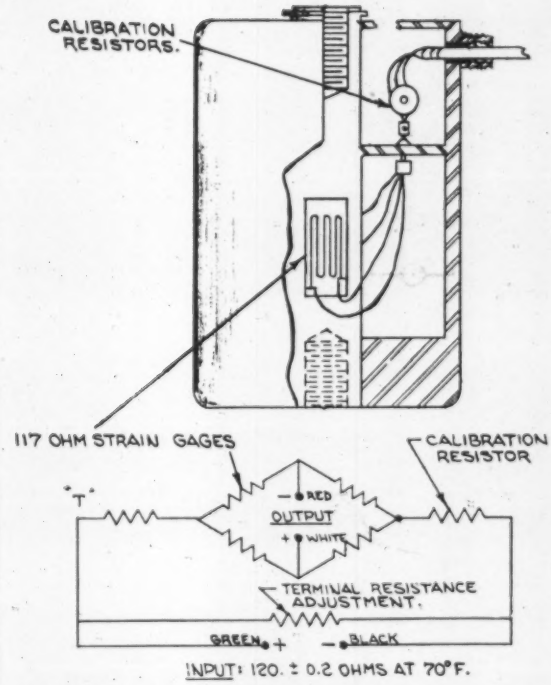


Fig 2. Details of load cell and bridge circuit.

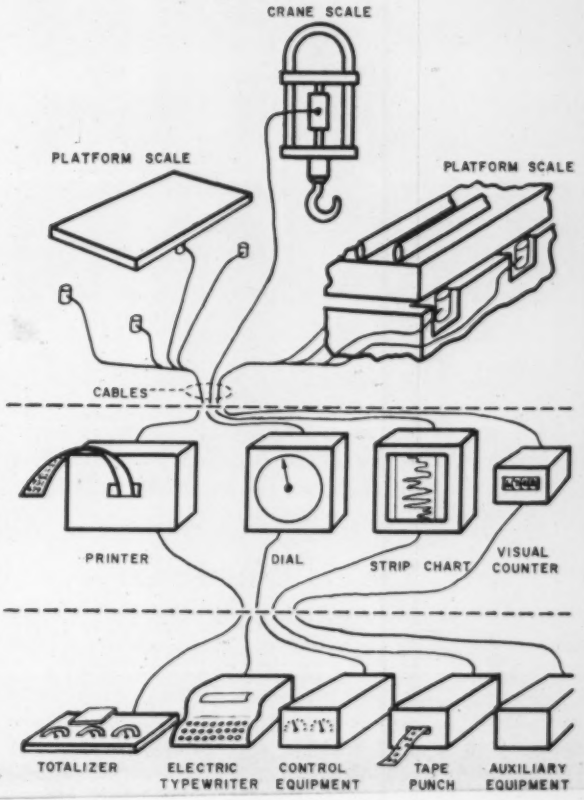


Fig. 3. Basic scale systems.

servo motor continues to run until the balance-bridge voltage (between points X and Y) is equal in magnitude to the load-cell voltage. The motor then stops because the two voltages cancel one another, leaving zero voltage impressed across the amplifier input terminals, or zero power to drive the motor.

The zero-adjust bridge, used to bring the recorder to a proper zero balance, consists of a separate voltage source and a potentiometer which serves as a voltage divider. Adjustment of this potentiometer permits one to (1) obtain a proper zero balance of the recorder by producing a voltage which is equal and opposite to any undesired voltage in the measuring circuit, (2) cancel any slight zero shifts which might occur due to temperature variation or other causes, and (3) cancel out the voltage due to a weighbridge or other form of load-receiving element on the load cells.

If *tare-weight compensation* is desired, a device similar to the zero-adjust control, consisting of another separate voltage source and potentiometer, is incorporated in the servo system. However, the potentiometer has a hand dial calibrated in weight units, which is set to the indicated tare weight for each load.

Data Presentation

As the angular displacement of the servomotor shaft is proportional to the applied weight, it may be used to position data-presentation elements such as pens, pointers, digit wheels, or printing mechanisms. Fig. 6 shows the step-cam and sensing-finger system which is used in some full-figure printing recorders to convert the angular displacement of the servomotor into discrete digits. Each sensing finger is pulled back to the waiting position while the motor rotates to a new balance point. Once the servomotor has brought the step cams to a new balance position, the sensing fingers move forward and engage the cams. As each sensing finger moves forward, its attached rack meshes with the pinion of its associated typewheel, and rotates the wheel to a printing position corresponding to the digit being detected on the step cam. As soon as all typewheels have been positioned, the print hammer snaps down and records the weight on a card or tape. The sensing fingers then move back to the waiting positions until the next weight is to be printed.

Limitations of Load Cells

Use of load cells requires consideration of four factors —excessive overloading, shock, eccentric loading, and rapid temperature change.

Excessive Overloading: Overloads up to 120 percent of rated cell capacity will not harm a cell mechanically or electrically. Overloads of 150 percent of rated cell capacity may cause a slight zero shift; if continually repeated, the life span of the cell will be shortened. Repeated overloads of 200 percent of rated capacity and greater will harm the cell.

Shock: Load cells, owing to high response speed, react to shock loads. The peak value of the impact force on a cell should not exceed 120 percent of its rated capacity.

Eccentric Loading: No mechanical harm will result if a lateral component of load force up to 25 percent of rated cell capacity is applied to the end of a cell perpendicular to the center axis of the loading column. However, such a lateral load force does introduce errors into the electrical measurement because the loading column is improperly deformed. Therefore, it is essential that the load force be exerted directly along the center axis of the loading column, at least when a reading is being taken.

Temperature: In general, load cells are well compensated for normal ambient temperature changes and are designed to operate at temperatures ranging from slightly

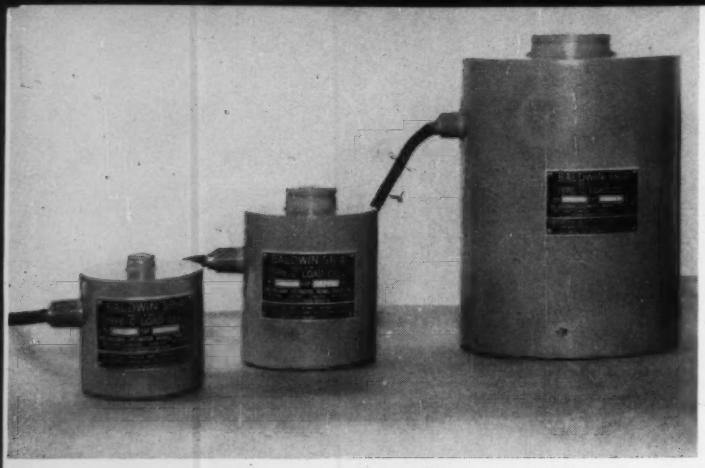


Fig. 4. Load cells of different capacities.

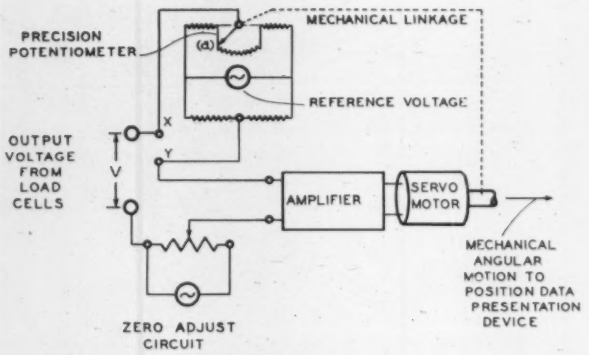


Fig. 5. Servo system.

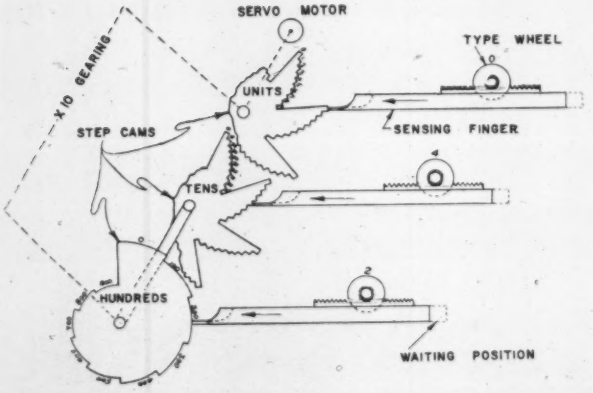


Fig. 6. Step-cam and sensing-finger unit for converting shaft position into discrete digits.

below 0 to a maximum of 150 deg. F. With precautions it is possible to operate the cells at somewhat higher and lower temperatures.

Other Load-cell Considerations

Sealing: Certain types of load cells are hermetically sealed and may be installed to operate under adverse conditions. Oil, water and dirt will not affect accuracy.

Number of Cells: Either a single cell or several cells may be used to support a load. Up to sixteen cells have been used to support a single weighbridge. When more than one cell is used, the electrical output terminals of the various cells are connected in series and the combined voltage thus obtained represents the total load supported.

Accuracy: The calibration accuracy of load cells normally used for weighing installation is 0.1 percent of rated capacity throughout the weighing range.

Load-cell Capacities: At present, available load-cell capacities are from 200 lbs. to 200,000 lbs.

Physical Dimensions: Small-capacity cells have over-all heights somewhat less than 5 inches, and outer diameters of approximately 3 inches; 200,000-lb.-rated-capacity cells have an approximate over-all height of 10 inches and outer diameter of 7 inches.

Tension and Compression: Usually, load cells are designed for use in either tension or compression.

A.C. or D.C.: Load cells may be operated on either a-c. or d-c. electrical power.

Distortion Under Load: Dimensionally, load cells change little when placed under load. The maximum deflection which may occur in the steel loading column for rated capacity load is of the order of 0.005 to .010 inch.

Interchangeability: In the event that a cell is damaged, it can be removed easily and a new cell mounted in its place.

Power Supply

At present, most electronic scales are designed to operate on a-c. power, principally because a transformer can provide the individual power supplies for the load cells and various measuring circuit elements—reference voltage, zero-adjust voltage, etc. The transformer used has a single primary winding and several secondary windings. The primary is connected to the power line; the secondary windings serve as individual power supplies.

An important advantage of this arrangement is that voltage fluctuations in the power line are reflected equally into each of the secondary windings. Therefore, the over-all scale circuit tends to maintain its same point of balance and does not appreciably change with power-line fluctuations. When power-line fluctuations become excessive, voltage-regulating equipment must be used.

The use of d-c. power poses regulation problems; a-c. power is preferred at present.

Cables

All cables in the load-cell circuit or general measuring circuit must be shielded and the shields grounded to prevent stray fields from influencing the scale. Where possible, cables should be installed in conduit.

In general, when using standard electronic-scale equipment, load cells may be located up to 200 feet from the recorder. Controlling factor in this regard is the temperature coefficient of resistance of the cable wires; if the interconnecting cables exceed 200 feet, normal temperature variation may cause sufficient line fluctuation (due to cable resistance variation) to affect the accuracy of the scale. However, with modified equipment it is possible to extend the distance beyond 200 feet.

System Considerations

Under normal industrial conditions the accuracy of electronic weighing systems is comparable with the best mechanical weighing systems. Weighing installations can be furnished to meet commercial tolerances recommended by the United States National Bureau of Standards. Electronic weighing has been officially accepted by all states to which a request for acceptance has been submitted.

The two most noteworthy aspects of electronic weighing are (1) the relatively small size of the load cells, and

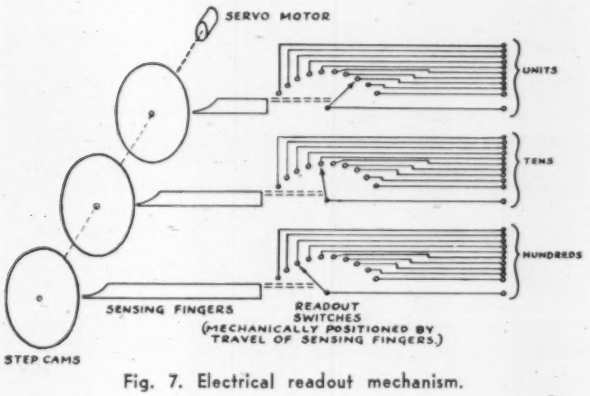


Fig. 7. Electrical readout mechanism.

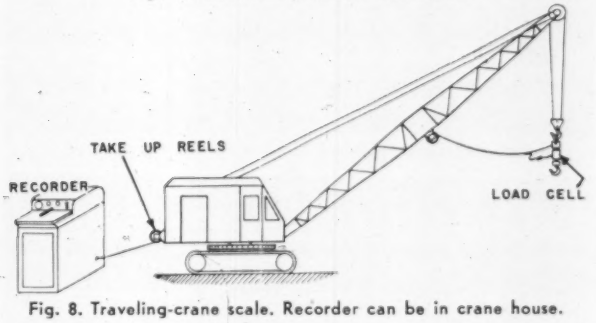


Fig. 8. Traveling-crane scale. Recorder can be in crane house.

(2) the fact that the weight information is conveyed by electrical signal through flexible cable. Thus remote and interconnected multi-station recording is possible.

Owing to the small size of the load cells, the structure of the scale may be kept at a minimum and highly functional designs are possible.

A wide variety of computational and control devices may be integrated into the basic instrumentation.

Electrical Readout

The electrical readout mechanism (Fig. 7) consists of a bank of wiping switches. Each switch has ten contact positions, representing the digits 0 to 9, and operates in conjunction with a specific sensing finger. From these switches, it is possible to deliver digitized weight information to tape punches, electrical typewriters, etc.

Control Devices

By attaching cams to the servomotor drive shaft to actuate switches at given points of rotation, and by utilizing other electrical components such as timers, many sequential controlling procedures are possible.

Use of Slip Clutch

In some weighing applications it is desirable to record incremental changes in load, rather than the total load on the scale. A slip clutch is incorporated between the servomotor and recording mechanism to accomplish this. For example, several different commodities may be placed on a blast-furnace scale car before it is dumped, yet it is necessary that the weight of each commodity be recorded. In this case, after each commodity is placed on the car scale and recorded, the slip clutch between the servomotor and step cams is temporarily disengaged while a return motor moves the recording mechanism back to the zero position. The clutch is then engaged again. As a result, only the weight of the following load will be recorded.

For "loss in weight feeding" applications, a similar procedure is followed.

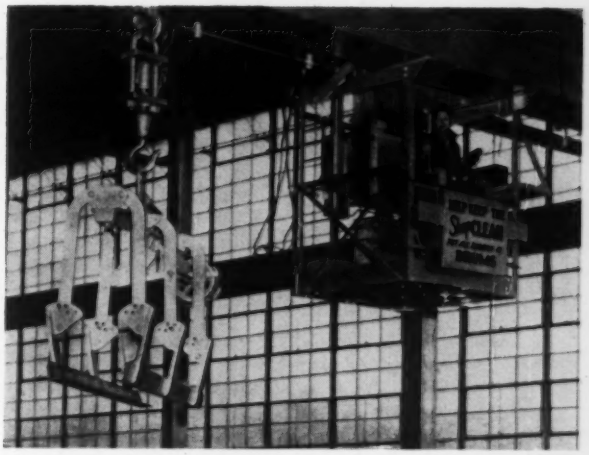


Fig. 9. Overhead-crane scale. Recorder or dial can be in crane house or on floor.

Crane Scales

One of the most important contributions made by electronic weighing in industry is that of the crane scale. Electronic crane scales combine transportation and weighing of heavy materials into one operation. The load detection unit (Fig. 9) is manufactured as a complete assembly and consists primarily of load cell with a lifting eye on top and conventional crane hook on bottom. A spring take-up reel gives out and takes up cable as the trolley moves; a remote recorder prints the weight of each load supported. Most crane installations can be converted into a scale simply by placing one of these load cell and hook assemblies on the existing crane hook and mounting the spring take-up reel and recorder at some appropriate point—usually in the operator's cab.

Freedom of travel for the crane is provided by use of a spring take-up reel or a looped conductor (Fig. 8).

For accurate reading, the crane must be stopped momentarily while the reading is being taken.

Safety Factors

A safety harness about the load cell (Fig. 9) is designed so that the load cell alone supports all loads within rated capacity. However, if the load cell should be overloaded or broken, the safety harness will support the load.

The hook of the load-detection unit is designed with a designated "weak spot." If an attempt were made to pick up an excessive overload, the hook would straighten out.

Modified Mechanical Beam Scales

For remote recording, or for space limitation problems, conventional mechanical beam scales sometimes are modified so that electronic weighing elements may be incorporated into them to readout the weight. When only remote recording is desired, a load cell (in tension) is mounted in the beam rod; the upper end of the beam rod is removed from the weighbeam, securely fixing it to some nearby support member. Thus, the same weight forces which were formerly balanced out by a counterpoise on the other end of the weighbeam are detected by the load cell. However, as the weight force detected by the load cell is a submultiple of the true weight on the scale, the instrument must also be calibrated in terms of the multiple; this is no problem. Load cells can be mounted in either tension or compression anywhere along the length of the transverse lever (Fig. 10).

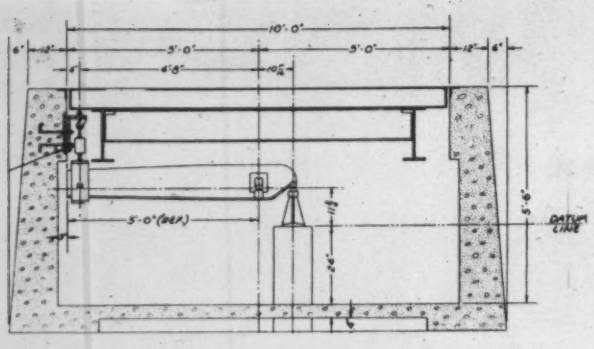


Fig. 10. Load cell adapted to shortened transverse lever of modified mechanical-beam scale.

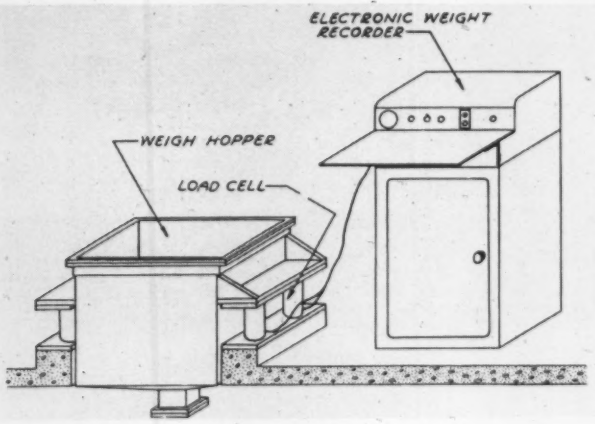


Fig. 12. Hopper supported by load cells.

Motion Weighing

Track Scales

Motion-weighing track scales for railroads, steelmills, mines, etc., are constructed by mounting load cells in a pit and placing a conventional weighbridge on top of the cells (Fig. 1). Pits for electronic scales are smaller than those required for conventional beam scales because of the small size of the load cells, plus the fact that there is no need for a transverse lever. Also, the size of the weighbridge can be reduced by installing several load cells to support it at many points.

Conveyor Scales

Load cells may be mounted in a section of the support structure of a conveyor line to provide a conveyor scale. For belt conveyors the instrument can indicate the rate of flow of material.

Monorail Scales

An existing monorail may be provided with weight determination by supporting a section of the rail with load cells (Fig. 11). Objects can be channeled along different routes according to weight classification by selective switching apparatus further down the rail line.

Hopper Applications

Fig. 12 shows how load cells can be used to support a hopper. Various batching sequences can be controlled by the instrumentation.

Rate-of-Flow Control

Use of electronic weighing elements in conjunction with a flow valve to control rate of flow deserves consideration. Fig. 13 suggests one possible use. Load cells support a tank from which molten sulphur is to flow at a certain rate. The controlling device consists essentially of a differential gear unit, a synchronous motor (constant speed), a rheostat, and a valve-actuating motor. The shaft at one end of the differential gear unit is connected to the servomotor; the shaft at the other end is connected to the synchronous motor. The center shaft is connected to the rheostat.

As the sulphur pours out, the change in weight causes the servomotor to rotate one side of the differential gear unit. The synchronous motor rotates the other side of the gear unit at a constant or predetermined speed. When proper rate of flow occurs, the two motors turn their respective sides of the gear unit at equal rates and the center shaft remains motionless. However, if the servomotor either leads or lags the synchronous motor, the center shaft turns, adjusts the rheostat, and repositions the valve until the proper rate of flow is established.

Future of Electronic Weighing

Electronic weighing still may be regarded as being in its infancy, in view of its ultimate potentialities. The fast response time will pave the way to various high-speed weight installations. Envisioned are electronic scales capable of detecting weights of vehicles moving at speeds of 60 mph. and greater. In crane scales, if the spring reel and interconnecting cable were replaced by a radio transmitter to transmit weight data from the load cell to the recorder, the versatility of the scale would be enhanced.

The small size of the load cell has yet to be exploited fully. The possibility of incorporating load cells directly into the lifting apparatus of a fork lift truck and installing a recorder on the dashboard is possible. Load cells and recorders could be installed in dump trucks, oil trucks, or other vehicles.

Forthcoming improvements will occur at an accelerated pace.

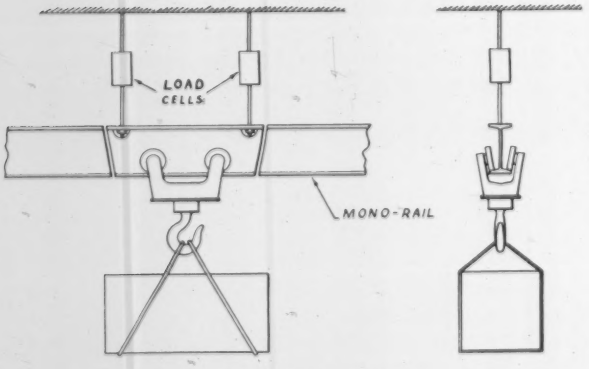


Fig. 11. Monorail scale.

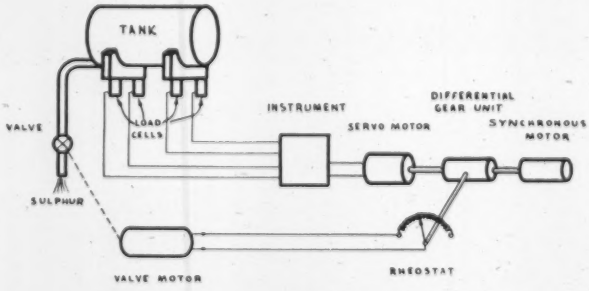


Fig. 13. Proposed rate-of-flow control system.

The Automatic Factory—
A Critical Examination

The prophets of doom, and those using historical evidence to predict technological unemployment, do not consider the hard-won stability of our modern industrial society. We are now conditioned to rapid technological change. However, individual managements should assume responsibility for their employees displaced or replaced by automatic techniques.

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VII. Social Implications Of The Automatic Factory

WHEN a businessman peruses the large volume of material which has been written on automaticity, he discovers a wide diversity of opinion regarding its effects on the American economy.

Examining some of these opinions, it becomes obvious that some writers may have developed predictions which lacked any reasonable and realistic perspective. Some persons already have predicted that the Age of Automaticity will be upon us in a brief space of time. It is claimed that at the height of this new "Era" the economy will be blessed with a tremendous increase in productivity producing an equally great increase in our standard of living. At this point, man will be blessed with large amounts of leisure, and the only problem which mankind must face will be the problem of learning how to live with one another. These writers are also predicting that the transitional period leading to the new "Golden Age" will create a great upheaval in our industrial society—that is, they believe that the Age of Automaticity with its huge increases in productivity per man hour will create an inevitable and Gargantuan unemployment problem. Consequently, industrial nations will be plagued with great social unrest which will manifest itself in widespread economic, sociological and political upheavals.

These conclusions have been developed by many writers. In *The Human Use of Human Beings*, Professor Norbert Weiner has expressed beliefs similar to those mentioned. In regard to the speed and the magnitude of the effect of the automatic factory on the economy, he said: "A rough estimate is that it will take the new tools ten to twenty years to come into their own." He also recognized the transitional effects of automaticity on the economy when he stated: ". . . the intermediate period of the introduction of the new means, . . . will lead to an immediate transitional period of disastrous confusion."

Professor Weiner analyses and describes the magnitude of this state of confusion in the following statement:

"Let us remember that the automatic machine, . . . is the precise economic equivalent of slave labor. Any labor which competes with slave labor must accept the economic conditions of slave labor. It is perfectly clear that this will produce an unemployment situation, in comparison with which the present recession and even the depression of the thirties will seem a pleasant joke."

Additional investigation of the recent writings on the automatic factory will turn up views written by persons who predict the opposite extreme—where the time span which now separates us from the Age of Automaticity is expressed in terms of *centuries*, not decades. Consequently, these diverse prognostications have compounded the difficulty the businessman faces in evaluating automaticity's true significance and its effect on the American economy.

The critical issue facing society is to what degree the automatic factory will influence our social and economic stability.

Historical Evidence

Contemporary writers often compare the effects of automaticity with historical events. This has resulted in predictions of social and economic upheavals similar to those of the 18th and 19th centuries. Such conclusions can be seriously questioned.

During the 18th century workers resisted mechanization. In this early stage of the Industrial Revolution the resistance took many forms of expression—legal restrictions, persecution, and even occasional machine-breaking riots. The inventor of the flying shuttle, John Kay, was forced to flee his country in 1773. Even Hargreaves had to change his residence because he invented the spinning jenny. In 1779, Crompton was compelled to go into hiding. The reaction to technological progress assumed nation-wide stature. England actually prohibited the manufacture of cotton fabrics until 1774.

If the reaction to mechanization was so violent when productivity increases were not as significant as they are today, then would not the risk of adverse reaction to automaticity be as great or even greater than was evidenced during the 18th century? The vital factor present in the early days but which no longer exists today is the *com-*

Prepared for General Georges F. Doriot in partial fulfillment of the requirements of the manufacturing course at the Harvard Graduate School of Business Administration.

"Society has become conditioned to the impact of technological changes"

pleteness of the changes produced by the Industrial Revolution. Predominantly agricultural and rural societies were transformed into industrialized and urbanized societies. The initial changes produced by the Industrial Revolution were changes of great magnitude, affecting all segments of society, breaking up the patriarchal family unit, cutting people away from the land, increasing specialization and interdependence of economic functions, realigning economic forces in society between industrial labor and capitalists, etc. Thus, technology, industrialization, urbanization were all new forces pushing and pulling society. Consequently, during the period of transition of society's adjustment to these new forces, the tensions produced sometimes caused violence. Presently, it is being prophesied that automaticity will repeat these sociological and economic upheavals.

However, these prognosticators overlook the fact that during the last two centuries of the Industrial Revolution society has become conditioned to the impact of technological changes in industrial mechanization. As a result, today both management and labor have developed enlightened policies toward mechanization. For example, in the 1948 contract, the United Automobile Workers, C.I.O., recognized officially that technological advances are for the benefit of both workers and capital. Thus, statements which predict a violent sociological reaction to the automatization of industry overlook the fact that society is conditioned and adjusted to technological change.

Also, it has been concluded in preceding chapters that automaticity will, in the near future, make gains only in small, highly mechanized segments of industry; and, further, the labor-displacing effects of these advances will be offset by the growth of other areas of industry and the economy. This is especially true in the distribution, entertainment and service segments. Therefore, those writers who use historical evidence to predict that automaticity will have instant effect on the economy as a whole, exaggerate the use of the past as a guidepost.

Social Problems

However, although the techniques of automaticity cannot be applied to the entire economy, and although the previously stated obstacles will deter the technological advances, use of automatic techniques will have a profound effect on local areas. Individual businessmen will have to use more-automatic machinery if they are to remain competitive. Because of this, many of the problems of automatizing American industry over the long run will have to be dealt with initially by individual plants in their local areas.

Granting that the effects of automaticity will be primarily localized, the business administrator can look forward to repercussions that will be to a large extent his own responsibility.

One of the key problems for which management will have to assume some responsibility is the labor displacement caused by automatic installations. Even though unemployment will be minimized by the increased requirements for maintenance personnel, it is also significant to realize the importance of the job assignments and skills that will become obsolete and undergo change.

Skill obsolescence to a man who is over forty might produce a number of adverse sociological and psychological reactions. Specifically, a worker, although still employed, will resent bitterly losing a certain job status and prestige, and having to develop habits for performing a new production task. A group of workers similarly affected and feeling insecure could amplify their resentment so that its manifestation would present a serious obstacle to good management, and could possibly upset industrial relations in the individual organization or industry.

Remedies to Social Effect

One method of combatting the labor problem is to upgrade and retrain the displaced workers for the highly specialized maintenance crews that become of increasing importance and scope in the "automatic factory." However, this function will call for increased abilities which some workers might not possess, and will necessitate an additional training program; an investment which management might not wish to make for older employees. In both of these cases workers could be transferred to those processes which will not be automatized immediately, such as assembly, and the total workforce reduced through normal turnover. Older workers could be retired prematurely.

However, in event of a rapidly expanding economy or industry—as is predicted for the U. S.—labor might merely be displaced, not replaced. If labor needs were reduced by one half, and twice as much production was demanded, the displaced employees could be utilized in the expansion. This phenomenon would occur if automaticity reduced costs to a point where demand was increased in proportion to the labor decreases.

Finally, management might find it necessary to relocate its employees either in the same community or industry. For example, within an industry or community two concerns might be producing the same product—one for a job-shop specialized market, the other for mass market. The former would automatize more slowly, and probably could absorb the labor displaced by the latter.

Conclusion

The preceding analysis indicates that there will not be a major upheaval in our society due to the movement toward the automatic factory, because the changes will be local and its evolutionary progress will vary even within industries. Also, the American economy is better equipped to absorb these changes in comparison to the economy of the 18th and 19th centuries.

However, this thesis does not negate the effects of automaticity on the individual plant and its locale. Problems will occur at this level, and must be conquered by management, labor, and government in cooperative endeavor.

"Use of automatic techniques will have a profound effect on local areas"

VIII. The Future

PROGRESS toward the automatic factory will be evolutionary. Developments will vary both in rate and in kind, depending on the industry and the company in question. For example, the oil and chemical industries will concentrate on obtaining feedback controls because they already have a continuous process. Discrete-unit producers, on the other hand, will concentrate on achieving continuous flow processes—a prerequisite for closed-loop control. In all industries, the nature of the obstacles to be overcome precludes any revolution in the area of automaticity. Nevertheless, it can be expected that the rate of evolution will be accelerated. A number of factors in our industrial scene contribute to this acceleration.

These "accelerators" include the following:

1. *Competition among equipment manufacturers.*

Example: Certain machine-tool manufacturers plan to add automatic controls and material-handling devices to their equipment. Their competitors will have to install similar and better units if they are to compete.

2. *Competition among equipment purchasers.*

Example: Application of "Project Tinkertoy" developments by producers of electronic products have resulted in substantial cost savings. These applications are spreading rapidly because of price competition within the industry.

3. *The need for balancing operations.*

Example: If an automatic installation in an oil refinery increases the rate of flow at one point, the preceding and following operations will have to be automatized if a continuous flow is to be maintained.

4. *The publicizing of automatic installations.*

Example: New magazines and the new interest in "automation" by all news services and publications are speeding up the dissemination of information on automaticity.

5. *The increased handling of dangerous materials.*

Example: As radioactive material cannot be handled by human beings, automatic handling must be developed.

6. *Return of the buyers' market.*

Example: A return of the buyers' market in the automobile industry has created new pressure on manufacturers to seek lower costs.

These are a few examples of factors which will accelerate the evolution of automaticity. The question arises—what developments will these factors foster in the future?

Future Developments

The following areas are those in which the authors expect advances in automaticity to be the greatest in the near future:

1. *More flexible automatic installations.*

Most of today's automatic equipment is custom made and can be utilized only by mass producers. The market for such devices is limited, and it can be expected that machines similar in principle to the M.I.T. numerically controlled milling machine will be developed. One machine builder is now constructing a machine which will carry out basic functions (drilling, milling, turning, etc.) in a variety of patterns controlled by input programs.

2. *Redesign of products, processes, and equipment.*

Redesign to permit automatic production will occur wherever the purchaser will accept the design simplicity essential for such production.

Thus, it can be predicted that redesign will take place *primarily* with regard to industrial products, where functionalism has long been the most important criterion.

However, consumer products, too, are now being influenced by a trend toward simplicity. As this trend gains momentum, redesign for automatic production will become increasingly attainable.

3. *Increasing interest in the materials-handling and control functions by machinery manufacturers.*

Companies will be more willing to expand large sums in the previously unrelated control and handling fields to develop automaticity in their own machines.

4. *Advanced training for engineers.*

Industry will send many of its engineers back to technical schools to receive advanced training, particularly in the field of systems engineering.

5. *Increasing attention to automatic assembly.*

In the future more and more attention will be devoted to automatic assembly because, as performed now, this phase of operations utilizes the greatest amount of labor and necessitates complicated, dexterous, and specialized skills. Much progress can be predicted in the area of sub-assemblies.

6. *"Automation" consulting firms.*

It can be expected that new and existing consulting firms will devote more and more of their time to the problems of automatic production. However, the work of these firms will be limited in scope (like the work of firms in Detroit on the installation of transfer machinery). It is unrealistic to expect in the near future that their use by manufacturers will result in extensive automatically controlled production processes. Even if such firms could assemble sufficient technical talent, the job of actually understanding production processes would still exist. So also would the obstacle of cost.

The foregoing are indications of what can be expected in the future in the area of automatic production. Fruitful realization of these developments will constitute the continuation of a centuries-old trend. Emotionalism will not contribute to an understanding of this trend. Only knowledge and good judgment will do the job.

Fig. 1. Non-indicating temperature controller.

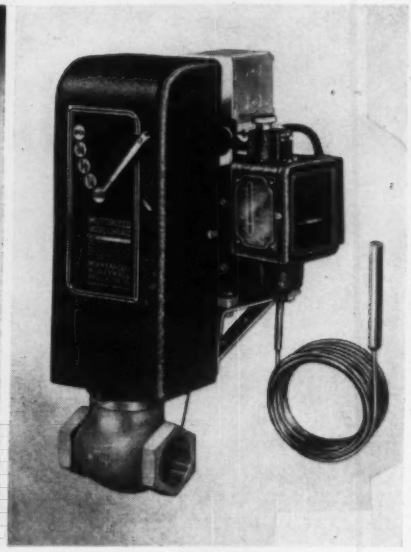


Fig. 2. Packaged temperature controller.

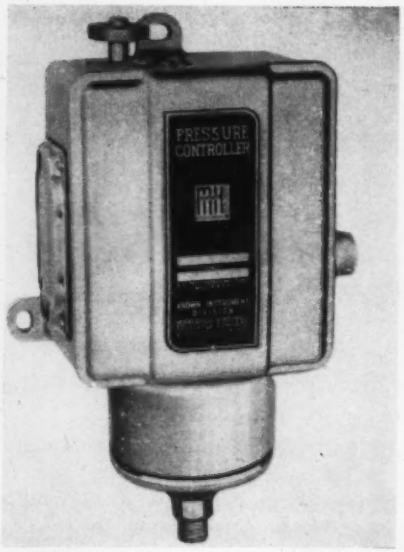


Fig. 3. Pneumatic pressure controller containing bellows that can operate either switch, potentiometer-resistor, or flapper-nozzle.

Do you know your basic

LOW-COST CONTROLLERS?

AS the complexity of instrumentation and automatic control equipment continues to increase, there is a tendency to overlook the economies that can be effected by use of low-cost controllers. Although difficult processing problems may require intricate and relatively costly equipment for automatic control, much can be done to improve products and save money and manpower by the application of simple, inexpensive controllers.

These low-cost units were designed originally for domestic and commercial use, to provide automatic temperature control for the heating systems of residences and public buildings. They were required to give years of dependable performance with little maintenance, and the size of the market necessitated mass-production techniques; these factors combined to produce reliable, economical units.

It was found that these inexpensive controllers could be used to advantage in industry; at present their purchases by industry account for many millions of dollars annually. Typical applications to be described include (1) complete control systems, (2) limit control applications, and (3) combination systems, in which the low-cost non-indicating controller is used in conjunction with indicating or recording controllers.

Presented before the Wilmington, Del. Section, ISA, September 29, 1954.

Temperature Control

In temperature controllers of the type illustrated in Fig. 1, the control

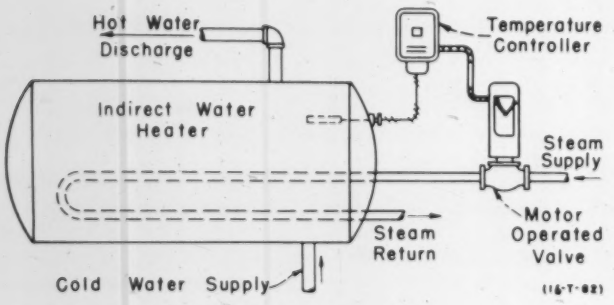


Fig. 4. Temperature control of water heater.

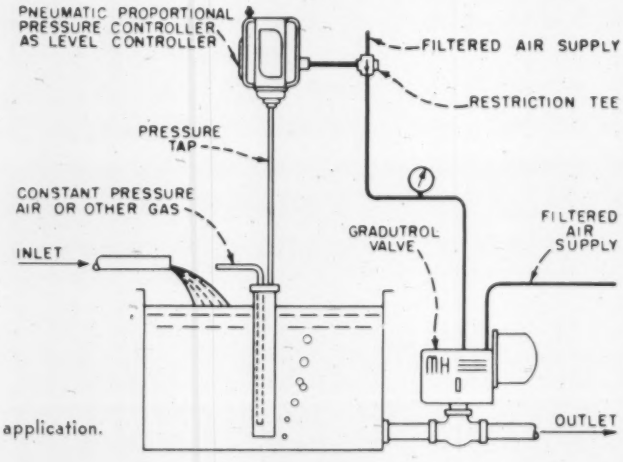


Fig. 5. Typical level-control application.

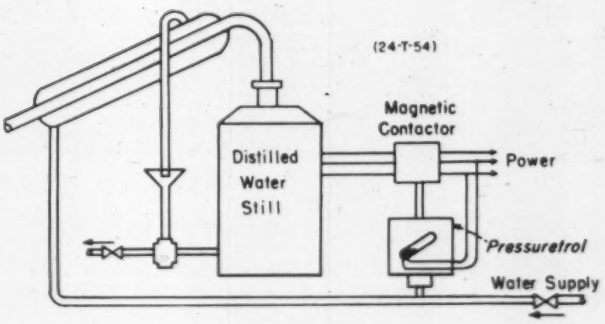


Fig. 6. Low-pressure safeguard controller for still.

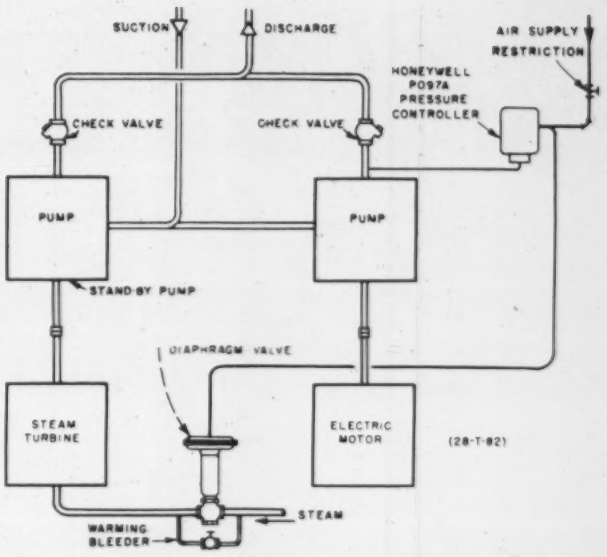


Fig. 7. Stand-by-pump cut-in control.

R. R. WEST

Minneapolis-Honeywell Regulator Company

While learning about the new developments in servo-operated integrated-feedback diode-matrixed digitized-readout control systems, don't lose sight of the simple, basic, standard low-cost controllers. The simple approach is often the best. Here are 20 typical applications of simple, inexpensive, versatile controllers.

mechanism is actuated by a vapor-pressure system comprising bellows, tubing, and bulb. A bellows, in the controller case, is connected by capillary tubing to the bulb, which is exposed to the variable to be controlled. Motion of the bellows is transmitted through suitable linkages to the control mechanism. On-off or proportional electric control, or pneumatic control, can be supplied. This type of controller is available for temperature ranges between minus 50 and plus 700 F.

A system using this controller is illustrated in Fig. 4. Cold water to a process is being heated by steam in a water heater. The bulb of the controller is installed in the heater and the control mechanism actuates an electric motorized valve in the steam line. A "packaged" system for this control function is shown in Fig. 2; this is a "packaged" electric temperature control system comprising a remote bulb controller and a motorized valve. The two units are combined in a single assembly, facilitating installation and maintenance. A wide choice of temperature ranges and valve sizes is available.

Pressure Control

Inexpensive pressure (or compound pressure and vacuum) controllers of the type illustrated in Fig. 3 can provide reliable electric or pneumatic control for many processes. The process pressure actuates a bellows which is linked to either (1) a switch, (2) a potentiometer-type resistor, or (3) a flapper and nozzle mechanism, depending on whether the controller is an electric on-off, electric proportional, or a pneumatic control model.

Open-tank Level Control

In Fig. 5 a pneumatic controller is used to regulate liquid level in an open tank. A conventional bubbler system provides the signal to the controller; when the tank level falls below the set point, a decrease in pressure in the bubbler system moves the controller bellows, actuating the flapper-and-nozzle mechanism to change the pressure in the pneumatic-valve circuit, thereby reducing the quantity of liquid flowing through the outlet.

Still Safeguard

Fig. 6 illustrates a system devised to safeguard a distilled-water still. Cooling water is supplied continuously to the still, and heat is applied by an element connected (through a magnetic contactor) to a three-phase power source. If the cooling water supply should fail, the heat would burn out the still; hence the need for a safeguard.

Installed in the water supply line is a "Pressuretrol" unit—an electric pressure controller, in which the bellows actuates a two-position mercury switch. When water supply pressure falls below the cut-out point, the magnetic contactor is de-energized, causing power to be disconnected from the still heater.

Stand-by Pump Control

Fig. 7 illustrates how a pneumatic pressure controller is used to automatically cut in a steam-driven stand-by pump in event of power failure at a motor-operated pump. The two pumps are connected to the same

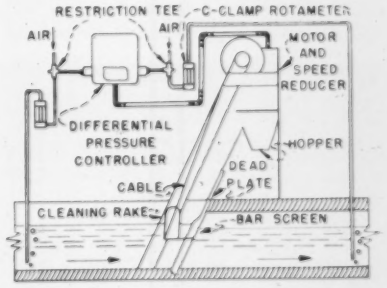


Fig. 8. Control of bar-screen cleaning rake by differential-pressure controller.

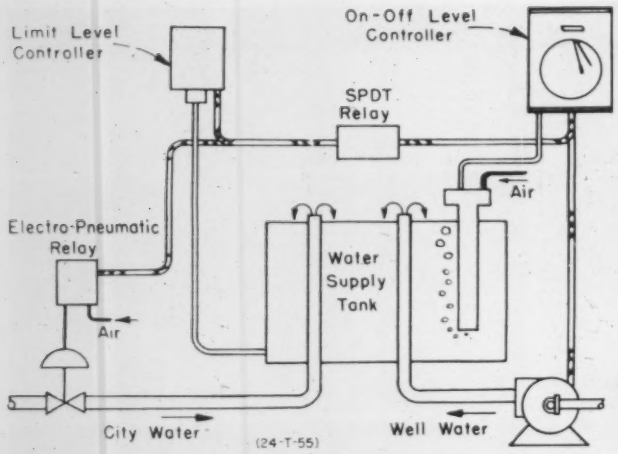


Fig. 9. Level-control system for dual-supply water system.

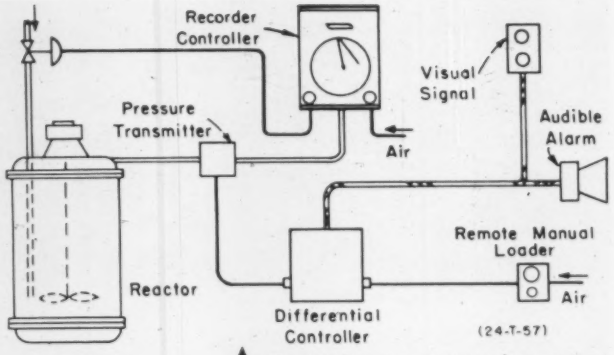


Fig. 10. Reactor-pressure alarm system.

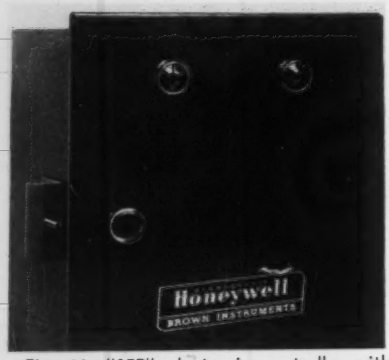


Fig. 11. "077" electronic controller with dual control units for cascade control.

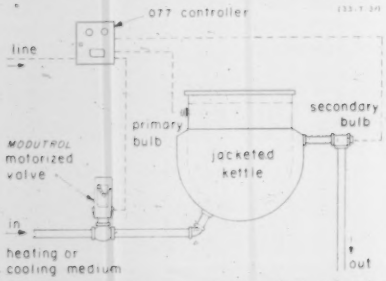


Fig. 12. Cascade control of jacketed kettle.

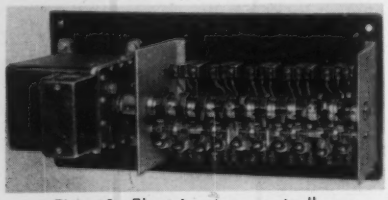


Fig. 13. Electric step controller.

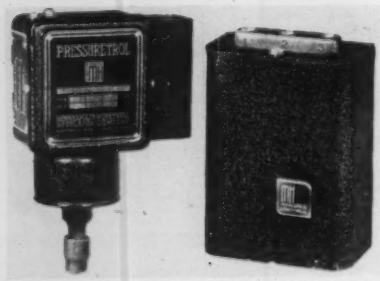


Fig. 14. Pneumatic-electric (left) and electric-pneumatic (right) relays.

suction and discharge lines. A pressure tap is made in the discharge line of the electric pump. This tap feeds into a pneumatic pressure controller that positions a pneumatic diaphragm-motor valve in the steam feed line to the turbine-driven stand-by pump.

If electric power fails, the electric pump stops, the pressure ahead of the check valve falls quickly to suction pressure, and the pressure controller opens the diaphragm valve in the steam feed line to the turbine-driven pump.

Differential-pressure Control of Bar Screen Rake

A differential-pressure controller contains two bellows assemblies, and controls on the basis of the difference between two pressures. A typical application is shown in Fig. 8. Here a power-driven bar screen cleaning rake, as used in sewage disposal installations, is operated by an electric differential-pressure controller when accumulation of solids on the screen restricts the flow to an undesirable extent. Such an accumulation increases the level on the upstream side of the screen. The differential-pressure controller, being sensitive to the difference in levels between the upstream and downstream side, actuates an electrically-driven cleaning rake when this difference reaches the predetermined controller setting.

Combination Systems

Figs. 9 and 10 illustrate combination systems in which non-indicating pressure controllers are used in conjunction with recording control instruments.

Dual-supply Water System

Fig. 9 shows a dual liquid-level control system for a water supply tank. Water for the tank is available from either a deep well or from city water supply; the low-cost well water is used as long as the supply lasts. A recording electric controller operates the well pump, and a non-indicating controller is used to regulate the supply of city water.

The recording instrument measures the level in the tank and operates the pump until the tank has been filled from the well water supply. However, when the well water pump is not able to supply sufficient water due to unusual plant consumption, city water must be used. A non-indicating electric pressure controller, designated "limit level controller," is set to admit city water through an air-operated valve when the level of the well water in the tank falls below a predetermined value. An electric-pneumatic relay provides the required link between the electric controller and the air-operated valve.

Reactor Pressure Control

In Fig. 10, a differential-pressure controller provides the means for an adjustable alarm setting in a system controlling pressure in a reactor.

Final reactor pressure is controlled by a pneumatic recording controller, but an alarm is necessary at an intermediate point before the final pressure is reached, and this point depends on the particular characteristics of the process being carried out. A differential-pressure controller is used to give the alarm at any preset pressure.

In operation, the set point of the differential controller is set at zero. By means of the remote manual loader, the air pressure on one bellows is

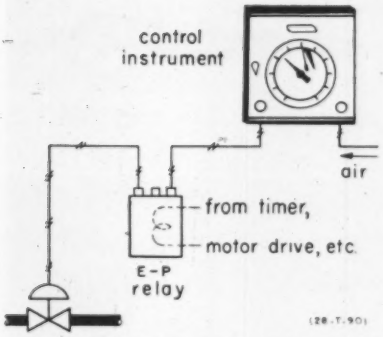


Fig. 15. Electric-pneumatic relay used in pneumatic control circuit.

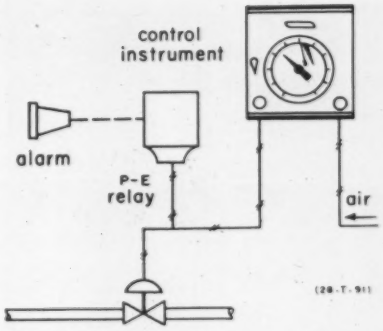


Fig. 16. Application of pneumatic-electric relay.

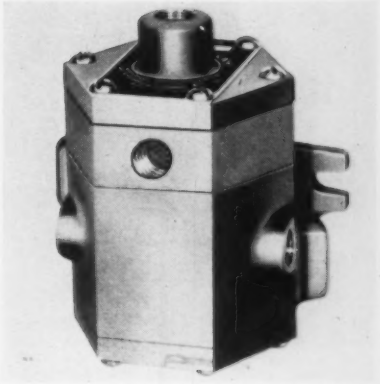


Fig. 17. Pneumatic averaging relay.

adjusted to a value equal to the desired reactor-pressure alarm point. When the pressure in the reactor increases, the pressure in the second bellows approaches that of the manually loaded bellows; when the two are equal, there is zero differential and the alarm is energized. Using this system, it is possible to reset the alarm point any number of times from the remote manual loading station, and pressure can be increased or decreased in a series of steps.

Cascade Control of Kettle Temperature

The "077" electronic temperature controller (Fig. 11), designed for exacting industrial applications, employs resistance thermometer bulbs as sensing elements, and operates between the limits of –100 and +600 F. Available for on-off, floating, or proportional electric control, the "077" controller can provide cascade control using two bulbs, as in Fig. 12.

Assume that the liquid in the jacketed kettle is being controlled at 150 F. The heating medium is water, which enters at 200 and leaves at 180 F. The control point of the bulb in the kettle is 150 F. The control point of the secondary element, in the outlet water, is 180 F. If the outlet water temperature drops, the secondary bulb will adjust the valve position before the load change is detected by the primary bulb.

Additional load in the kettle, in turn, will cause the temperature in the kettle to drop at the primary bulb. Under this circumstance the correction will be made at the valve before any change is detected at the secondary bulb in the outlet water.

A sensitivity adjustment in the controller determines the percentage of control (or "authority") the secondary bulb has over the control valve. At one extreme of adjustment, the secondary bulb has little effect on the valve; at the other extreme, the effect of both elements is equal.

Sequence Control

A sequence or "step" controller (Fig. 13) can be used in conjunction with temperature or pressure controllers to operate multiple electrical loads in any desired sequence. It comprises, essentially, an electric-motor-driven rotating shaft to which are attached several adjustable cams that can be set to operate a number of mercury switches at different points during the shaft rotation. In this manner, electrical loads can be energized or de-energized in succession on a pre-determined schedule.

Relays Link Pneumatic and Electric Circuits

Pneumatic-electric and electric-pneumatic relays are inexpensive devices used where interlocking between electrical and pneumatic circuits are required—where a pneumatic controller must actuate a visual signal or audible alarm in addition to operating a diaphragm motor valve, or where an electric timing device is required to initiate the operation of a pneumatic control system. These relays (Fig. 14) provide the "linkage" between electric and pneumatic components.

In Fig. 15, an electric-pneumatic relay is installed in the air line from a pneumatic controller to a diaphragm-motor valve. When the relay is energized—by a timer, for example—the port arrangement of the relay connects the valve to the controller; when the relay is de-energized, however, the line between the valve and the relay is connected to a port venting to atmosphere. In a batch heating process, for example, the valve would be of the air-to-open type so that it would close when the relay was de-energized, stopping the flow of fuel or steam to the process.

An application of the pneumatic-electric relay is illustrated in Fig. 16. The relay is installed in the controlled-air line from a temperature

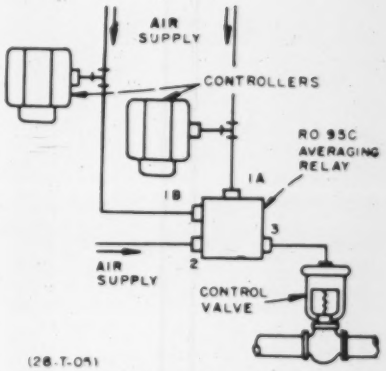


Fig. 18. Application of averaging relay.

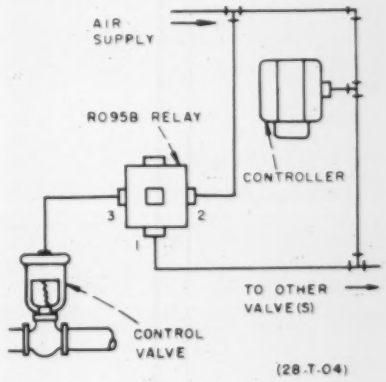


Fig. 19. Application of reversing relay.

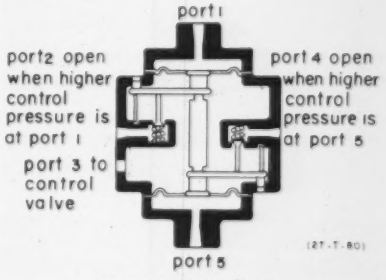

port 1
port 2 open when higher control pressure is at port 1
port 4 open when higher control pressure is at port 5
port 3 to control valve
port 5
(27-T-80)

Fig. 20. Selective relay.

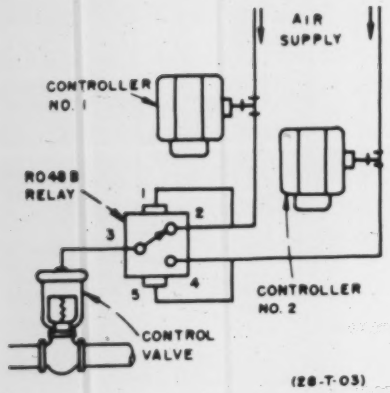


Fig. 21. Application of selective relay.

controller to a diaphragm-motor valve. When the pneumatic signal from the controller exceeds the pressure at which the relay is set, the alarm is energized. This arrangement is used to provide either low-limit or high-limit signals in conjunction with control operations.

Pneumatic Relays

Pneumatic relays (Fig. 17) are integral parts of many control systems; they receive one or two controlled-air pressures and, by means of an inner valve system, transmit a modified or diverted pressure.

Fig. 18 is an application of an averaging relay whereby the pneumatic output of two controllers is modified into an average output to the valve.

A *reversing relay* operates in conjunction with a pneumatic controller to decrease air pressure to a control valve as the controller's output pressure increases. It can be used in applications where one controller is operating two or more valves, one of which would, for example, close on 15-psi. pressure while the remaining valve or valves would open on 15-psi. pressure (Fig. 19).

A *selective relay* (Fig. 20) is used to put the control valve under the authority of either of two controllers having the higher output pressure. If the pressure applied to port 1 is greater than that applied to port 5, air will flow between ports 2 and 3. When pressure applied to port 5 exceeds that applied to port 1, air will flow between ports 3 and 4. This relay is applied as in Fig. 21.

The "*snap-acting*" *relay* (Fig. 22) transforms gradual air-pressure change from a pneumatic controller to a positive on-off-type air-pressure change for a control valve. It is used on pneumatic control applications requiring two-position operation where, for example, a valve must receive

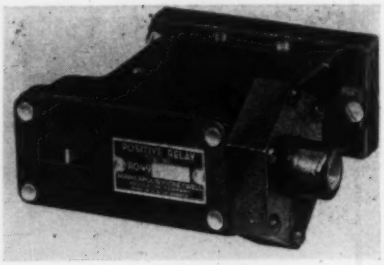


Fig. 22. Snap-acting relay.

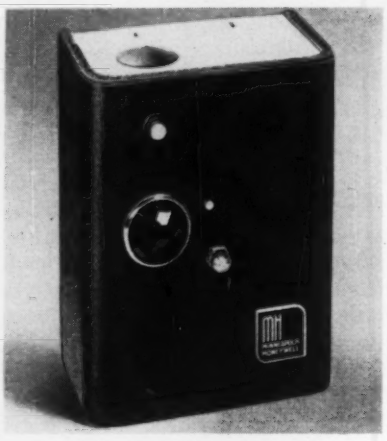


Fig. 23. Alarm-silencing relay.

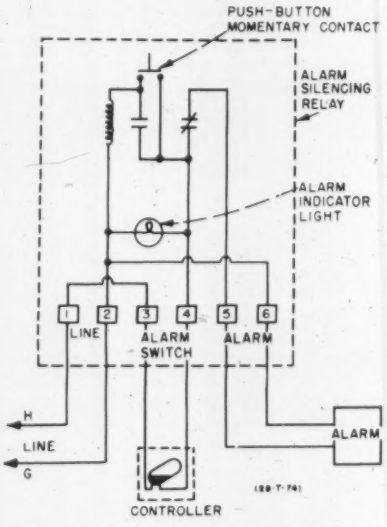


Fig. 24. Application of alarm-silencing relay.

0-psi. controlled-air pressure for its fully closed position, no intermediate positions or modulating action being desired.

Alarm-Silencing Relay

Used in conjunction with temperature or pressure controllers, or flame failure safeguard systems, the alarm-silencing relay (Fig. 23) provides the means for de-energizing an audible alarm and at the same time retaining a visual indication that a limit has been reached or exceeded.

Operation of the alarm-silencing relay is shown in Fig. 24. With the con-

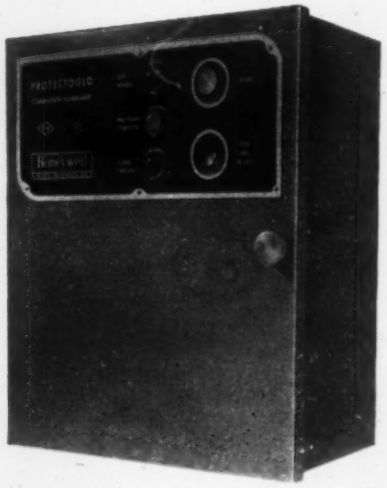


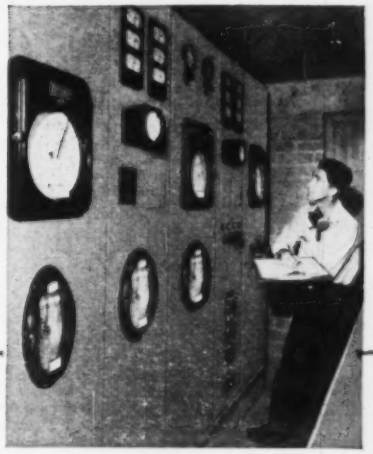
Fig. 25. "Protectoglo" relay.

troller contact made, an alarm indicator light in the relay is energized, and the alarm is also energized through the normally closed contact of the relay. When the push button is depressed, this contact is opened and the alarm circuit is broken. The normally open contact of the relay forms a relay holding circuit in parallel with the red alarm indicator light. Although the alarm is silenced, the alarm indicator light will remain on until the controller contact is broken; when the controller contact breaks, the alarm circuit is reset.

Combustion Safeguards

Industry requires systems to protect against explosion hazards attendant upon flame failure in furnaces, ovens, kilns, or other heating equipment. "*Flame rectification*" has proved to be a foolproof method of flame-failure protection. In gas-fired applications, an electrode or "flame rod" is arranged to contact the flame directly; the electrode assembly and flame are included in an electrical circuit which is energized when the flame is present, de-energized in the event of flame failure. A "Protectoglo" relay (Fig. 25) is the "nerve center" of the system; on flame failure this relay operates to shut off the fuel supply immediately. The relay illustrated is a new design with "start" and "stop" pushbuttons, and three signal lights on the front of the case. One light indicates "power on," and is lit when the system is in operation. The second light signals "purge completed"; this light is used when the safeguard system incorporates a timed interval during which the combustion space is purged of any accumulation of unburned fuel. The third light denotes "flame on" and remains lit as long as the flame is present.

For All Your Meters, Instruments, Recorders . . .



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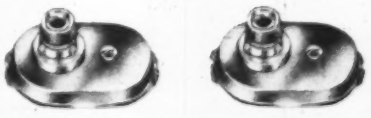
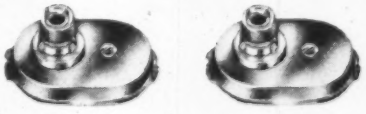


8-HOUR 12-HOUR

6-HOUR 48-HOUR

4-HOUR 72-HOUR



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Hydraulic techniques for

PISTON-OPERATED VALVES

New techniques are presented both for remote manual positioning of piston-operated valves and for use of piston operators for pressure-controlling valves. A valve positioner, pilot valve, and oil pump can be used with the piston operator to effect pressure control with low maintenance.

F. M. PARTRIDGE and **G. C. WILSON**

Southern California Gas Company

FROM time to time attempts have been made to use plug valves as regulators in order (1) to minimize pressure drop through the valve under wide-open conditions, and (2) to solve the noise problem by burying the plug valve and operating it through extended gearing. Plug-valve pressure control has been accomplished by using air motors or electric motors operating through suitable gearing, and controlled by various methods.

Engineers often have considered the use of a piston-operated plug valve for throttling purposes. Experience had shown, however, that it is difficult to position the valve accurately with an air-operated piston. Owing to leakage past the piston cups, the static friction of the valve and cylinder, and the compressibility of the gas in the cylinder, it has been found almost impossible to stop the valve once it starts to move, thus hunting resulted. If these three problems could be solved, it would be possible not only to use plug valves as regulators in new stations, but also to install cylinders on existing valves and use them for control purposes. The conversion of an existing valve to a control valve without taking it out of service and at the relatively low cost of a power cylinder and positioning equipment is an attractive proposition.

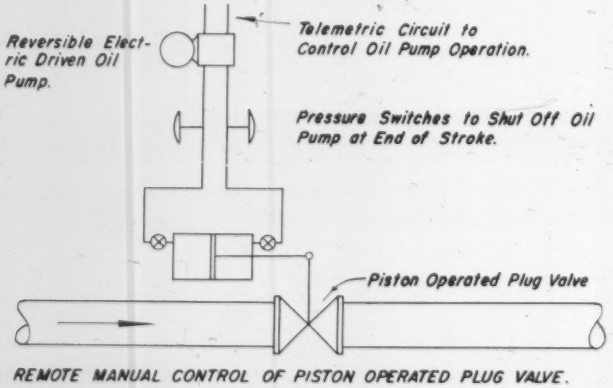

Reversible Electric Driven Oil Pump.
Telemetric Circuit to Control Oil Pump Operation.
Pressure Switches to Shut Off Oil Pump at End of Stroke.
Piston Operated Plug Valve
REMOTE MANUAL CONTROL OF PISTON OPERATED PLUG VALVE.

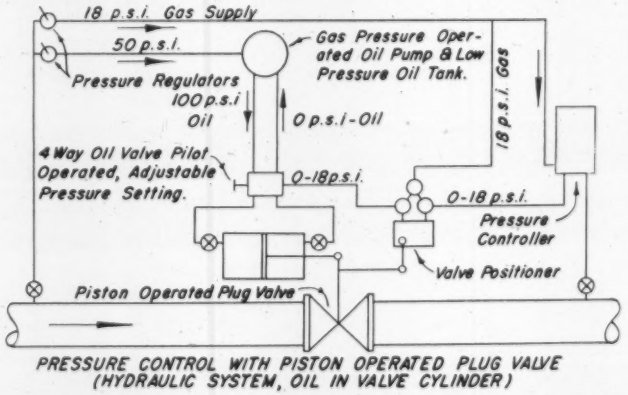
Fig. 1. Remote manual control of piston-operated plug valve.

The first attempts to accomplish the desired valve control were made using a pneumatic valve positioner and a 4-way valve, with gas pressure used to move the piston. Although fairly satisfactory outlet-pressure control could be attained, it was difficult to eliminate the constant "hunting" of the valve. The maintenance of the piston cups and gas leakage past the piston were other factors which made this type of control unsatisfactory. (Although gas is used in our control work, air could be used.)

There are two objectives desired in positioning valves —(1) remote valve positioning at any desired point and (2) pressure or volume control.

Remote Valve Positioning

The first, and perhaps simplest objective, is remote valve positioning—that is, positioning the valve from some remote location similar to manual control by a human operator at the valve location. When a valve is to be opened between two systems appreciably different in pressure, it is desirable (if not absolutely necessary) to open the valve slowly, and often to hold the valve in an intermediate position. This could be done with a motor-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0-18 p.s.i.
Pressure Controller
Valve Positioner
Piston Operated Plug Valve
PRESSURE CONTROL WITH PISTON OPERATED PLUG VALVE (HYDRAULIC SYSTEM, OIL IN VALVE CYLINDER)

Fig. 2. Pressure control with piston-operated plug valve. Hydraulic system uses oil to operate cylinder operator.

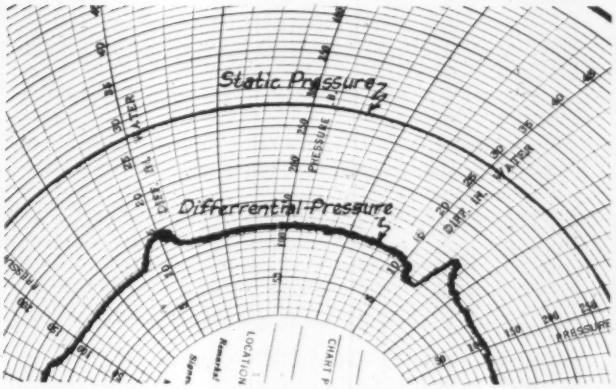

Fig. 3. Chart showing static and differential pressures downstream of experimental plug valve. Each time unit represents 1 minute on 96-minute chart.

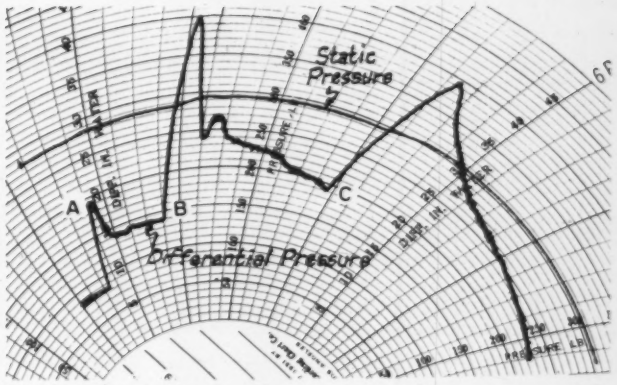

Fig. 4. Static and differential pressures downstream of experimental plug valve when changes in pressure setting were made. Each time interval represents 1 minute on 96-minute chart.

operated gear-driven valve, but use of a cylinder operator offers greater flexibility; also, the cylinder operator often can be installed on existing valves without taking them out of service.

Use of Hydraulic Pump

To position the valve by a piston, oil is pumped from one side of the piston to the other by a small aircraft-type electric-hydraulic pump. Filling the cylinder with oil eliminates the three main difficulties usually encountered in positioning piston-operated valves, which are (1) leakage past the piston cups, (2) high static-friction, and (3) the compressibility of the gas in the cylinder. The speed of valve movement can be controlled readily by a variable or fixed restriction in the oil line to the cylinder; the valve can be positioned accurately. Sufficient pressure is made available so that when the pump starts operating, the valve moves immediately because of the incompressibility of the oil.

A schematic diagram of the piping arrangement for this method of valve positioning is shown in Fig. 1. A reservoir must be supplied for excess oil, and the amount of valve movement per unit of time should be determined for the operator. An air-powered pump (using gas pressure) could be used for this service, but if electric power is required for the telemetric controls, it can be conveniently used for operating the pump.

Pressure Control

The second basic objective—pressure control—requires a more complex setup in order to position a piston-operated valve. A pressure-controlling setup is shown in Fig. 2. A conventional pneumatic pressure controller (shown at right) is used, the output of which feeds into an external-lever-type valve positioner, which is connected to the valve plug through mechanical linkage. The output of the valve positioner is connected to operate a 4-way adjustable pilot valve. This valve has a neutral position so that when the output pressure of the positioner is approximately 8.5 psi., the 4-way valve is closed and the piston-operated valve is at rest.

The 4-way valve controls the output of a simple air-liquid reciprocating pump such as is used for pumping heavy oil in a service station. As the pump had a 2-to-1 pressure ratio, with a gas pressure supply of 50 psi. the pump delivers oil at about 100 psi. to the supply connection of the 4-way valve. Whenever the 4-way valve moves (to permit oil to flow into the valve cylinder), the oil pump starts to operate. The oil pump is mounted on a light-weight vessel in which the oil is stored at atmospheric pressure. The vent or exhaust connection of the 4-way valve is connected to this oil reservoir so that exhaust oil from the valve cylinder is returned to storage and re-used. Gas at 50 psi. pressure is supplied to operate the reciprocating air-liquid pump, and gas at 18 psi. is supplied to the valve positioner and to the controller.

A section of an orifice-meter chart from a meter downstream of the pressure controlling valve is shown in Fig. 3. This chart shows the smooth control produced.

The static and differential-pressure records during pressure-setting changes are shown in Fig. 4. The charts are from a 30-inch orifice meter immediately downstream from the test valve, which was a 12-inch buried plug valve. The upsets shown were caused by: At point A, control point was raised 5 psi.; at point B, control was raised 10 psi.; at C, control point was raised 10 psi., with oil flow restricted to slow down the piston speed.

Conclusion

Use of oil in the valve cylinder makes it convenient to position piston-operated valves accurately either for remote control or for automatic pressure or volume control. The following additional advantages can be realized:

1. The oil-filled cylinder reduces maintenance, particularly of the piston cups.
2. Most valves can be converted to remote or automatic control by installing an operating cylinder and positioning equipment, without taking the valves out of service.
3. In event of failure of the oil system, the valve will probably remain in its operating position. This generally is preferable to the conventional control valve which either closes or opens wide when failure occurs.
4. Complex pressure-limiting stations could be eliminated by putting this type of control equipment on a main line valve.

Some experience has been obtained to indicate that plug valves are resistant to abrasive wear on the body and on the plug when used for control work; however, for operations under severe or questionable conditions, it is recommended that provision be made for periodic inspection of the valve interior. This may require the installation of upstream and downstream block valves and a bypass, as in conventional regulator installations.

Although plug valves were used in the control work described, the techniques apply to any kind of valve.

March Meeting: *Thursday, the 17th, Rio Hondo Country Club, Downey, Calif.*

Feature: *Richard I. Barlow, Pannellit, Inc., will present a paper on "Probable Effect of Information Systems on the Graphic Panel."*

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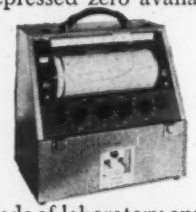

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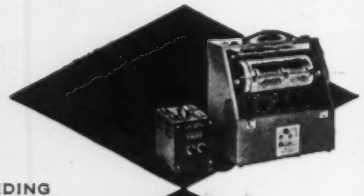

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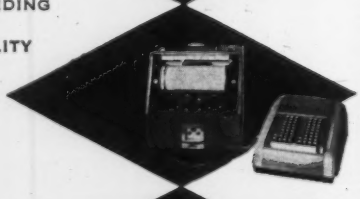

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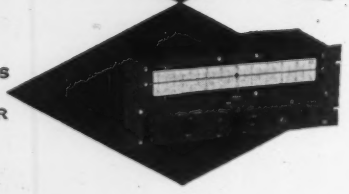

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Events...

February 23

New York Sec., Instrument Society of America Winter Conference will be held at Hotel Statler, N. Y. Theme: Instrumentation For Data Reduction and Presentation. For information contact: Hamilton Bristol, Bristol Co., 250 W. 57th St., N. Y., N. Y.

February 28-March 4

Sixth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, William Penn Hotel, Pittsburgh. For information write J. F. Miller, Mellon Institute, 4400 Fifth Ave., Pittsburgh 13, Penna.

March 1-3

1955 AIEE, IRE, and ACM Western Computer Conference and Exhibit will be held at the Statler Hotel in Los Angeles. For information write Institute of Radio Engineers, 1724 West Main St., Alhambra, Calif.

March 6-12

American Society of Photogrammetry and American Congress on Surveying & Mapping Consecutive Meetings will be held at Shoreham Hotel, Washington, D.C. For information write ASP Chairman J. W. Cain, 7004 17th Ave., Hyattsville, Maryland, or ASCM Chairman W. S. Dix, Rm. 435 Woodward Bldg., Washington 5, D.C.

March 8-10

Fifth Annual Conference on Instrumentation in the Iron and Steel Industry, sponsored by the Pittsburgh Sec., Instrument Society of America will be held at the Hotel William Penn, Pittsburgh, Pa. For information write A. F. Robbins, Crucible Steel Co., Midland, Pa.

March 11

Winter Meeting of Gulf Coast Spectroscopic Group will be held at Buccaneer Hotel, Galveston, Texas. For information write E. S. Rhodes, Carbon and Carbide Chemicals Co., P. O. Box 471, Texas City, Texas.

March 16-17

Panhandle Section of Instrument Society of America will hold their First Annual Instrument Show at Borger, Texas. For information write L. D. Kleiss, ISA, Panhandle Sec., P. O. Box 322, Phillips, Texas.

March 29

Cleveland Section of American Society for Quality Control will hold their first Annual One Day Quality Control Conference at Hotel Carter, Cleveland, Ohio. For information write G. K. Montgomery, Jack and Heinz, Inc., Cleveland 1, Ohio.

April 25-26
First National Conference of Instruments and Regulators Division of A.S.M.E. will be held at University of Michigan, Ann Arbor, Mich. For information write J. A. Hrones, Director Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass.

April 27-29
Society for Experimental Stress Analysis 1955 Spring Meeting will be held at Hotel Statler, Los Angeles, Calif. For information write W. M. Murray, P. O. Box 168, Central Square Station, Cambridge 39, Mass.

May 2-5
Annual Research Equipment Exhibit and Symposium in Instrument Techniques and Applications, National Institutes of Health, Bethesda, Maryland. For information, write to the Supply Management Branch of NIH.

May 14-22
Chemical Engineering and Equipment Exhibition at Frankfort, Germany. For information write Dechema, Rheingan-Allee 25, Frankfort/M, Germany.

May 23-27
Third Annual Conference on Mass Spectrometry, sponsored by the ASTM Committee E-14 will be held at the Mark Hopkins Hotel, San Francisco, Calif. For information write J. G. Hutton, General Electric Co., 1 River Rd., Schenectady, N. Y.

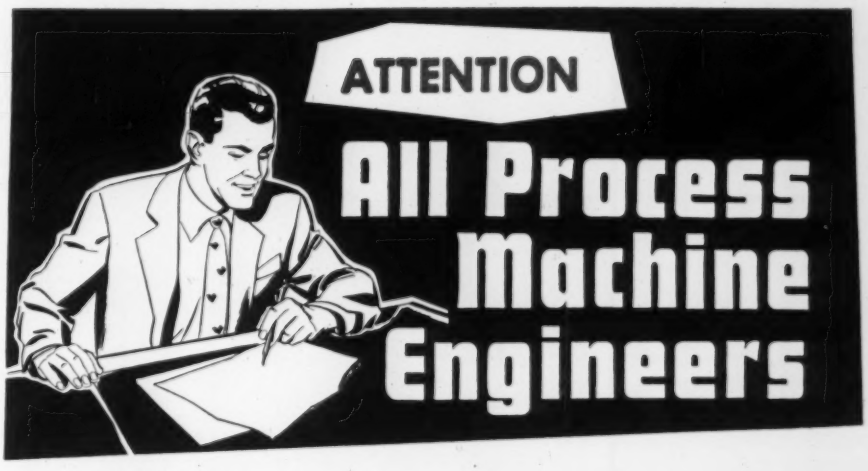
June 7-9
Committee on Vacuum Techniques, Inc., will hold their Second Symposium on Vacuum Technology at Mellon Institute, Pittsburgh 13, Penna. For information write Rudy Koehler, Committee on Vacuum Techniques, Inc., Box 1282, Boston 9, Mass.

June 9-10
Conference on Carbon will be held at University of Buffalo, Buffalo, N. Y. For information write Carbon Conference, Department of Physics, University of Buffalo, Buffalo, New York.

June 13-17
Annual Symposium on Molecular Structure and Spectroscopy, Ohio State University. For information write Prof. Harold H. Neilsen, Dept. of Physics, Ohio State University, Columbus 10, Ohio.

June 28-July 9
Third British Instrument Industries' Exposition at Earl's Court, London. For information write F. W. Bridges & Sons, Ltd., Grand Bldg., Trafalgar Square, London W. C. 2, England.

November 14-17
Second International Automation Exposition will be held at Chicago's Navy Pier. For information write The Second International Automation Exposition, 845 Ridge Ave., Pittsburgh 12, Penna.



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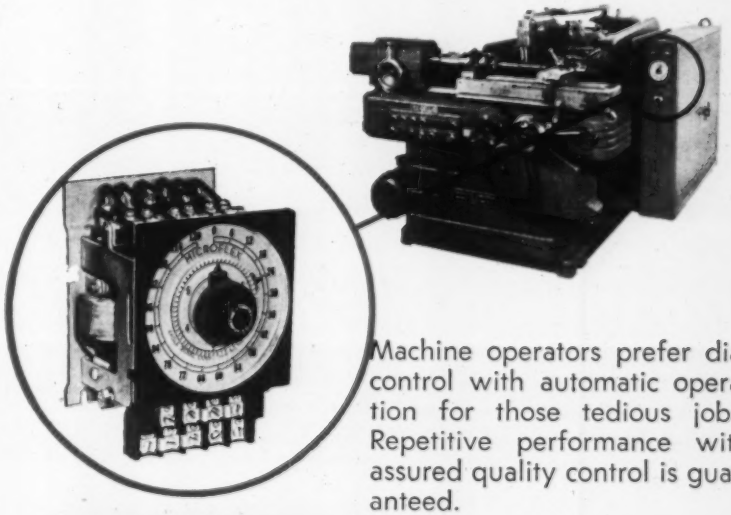

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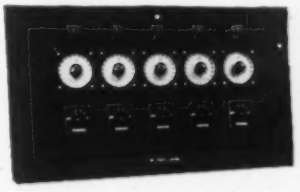

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Briefs . . .

INSTRUMENTS and AUTOMATION

Automation Dictionary

ANALOG COMPUTER. An electronic calculating machine which solves problems by translating conditions like flow, temperature, or pressure into electrical quantities.

CYBERNETICS (sy-ber-NET-ics) n. A new field of science which attempts to relate the operation of automatic devices to the automatic functioning of the human body's nervous system. Once accomplished, it hopes to evolve a theory blanketing the field of control and communication—both in machines and men.

DEVIATION. No change from the layman's definition—means the difference between the actual value of a condition and the one at which it is supposed to be controlled.

DERIVATIVE ACTION. Control operation in which the speed of a correction is made according to how fast a condition is going off-the-beam (same as rate action).

INSTRUMENTATION. Used to describe the application of industrial instruments to a process or manufacturing operation. Also describes the instruments themselves.

THERMISTOR (THERM-iss-tor). A special type of temperature sensing element. Its extreme sensitivity permits it to transmit a strong signal from a very tiny temperature change.

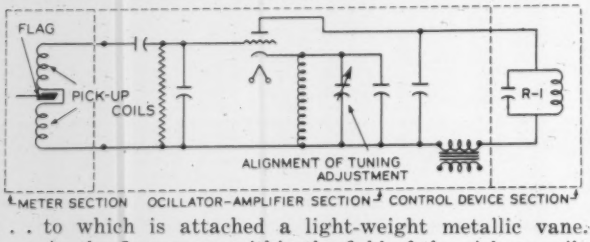
TRANSFER FUNCTIONS. Simply a mathematical expression of the control engineer which expresses the relationship between the outgoing and incoming signals of a process, or control element. Useful in studies of control problems.

(*From new 20-page "AUTOMATION DICTIONARY," Brown Inst. Div., Minn.-Honeywell Reg. Co., Philadelphia 44, Pa.*)

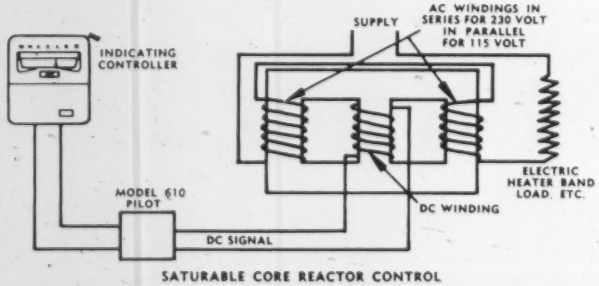
For this literature circle **501** on inquiry card.

Series 400 Capacitrols

The new 400 Series Capacitrols features a D'Arsonval-type measuring element, an "electronic link," and various types of control devices. The heart of the measuring circuit consists of a D'Arsonval galvanometer with a pointer



. . . to which is attached a light-weight metallic vane. . . . As the flag moves within the field of the pick-up coils it influences the oscillator to tune or detune it, which in turn regulates the power output to any of a variety of final control elements.



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For this literature circle **502** on inquiry card.

Meter-relay Controllers

Contact meters provide automatic locking relays for sensitive control of process or mechanical operations. . . . The contact locking arrangement was developed to build up contact pressure and separating force, both of which are usually missing in sensitive moving-coil relays.

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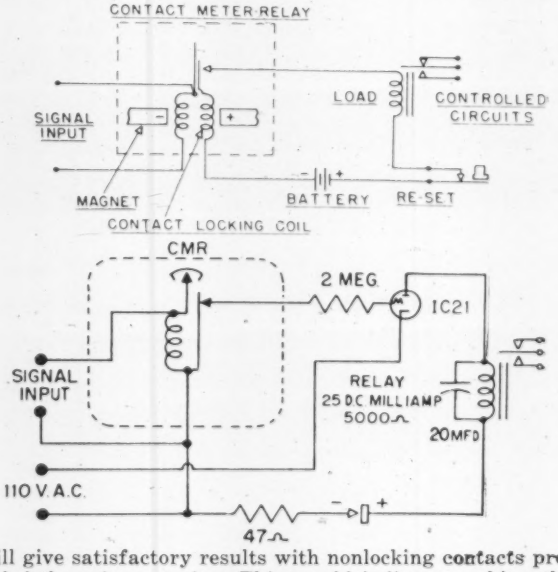

will give satisfactory results with nonlocking contacts provided there is no arcing. This would indicate working the contacts into an extremely sensitive relay or into a vacuum tube. The lower diagram shows a meter-relay and cold-cathode trigger tube which has given satisfactory results.

Normal contact life expectancy is several million with the locking coil; this might be reduced to several thousand with nonlocking contacts. (*From new 44-page Catalog 3-A, Assembly Products, Inc., Chesterland, Ohio.*)

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Orthosil Wound Cores

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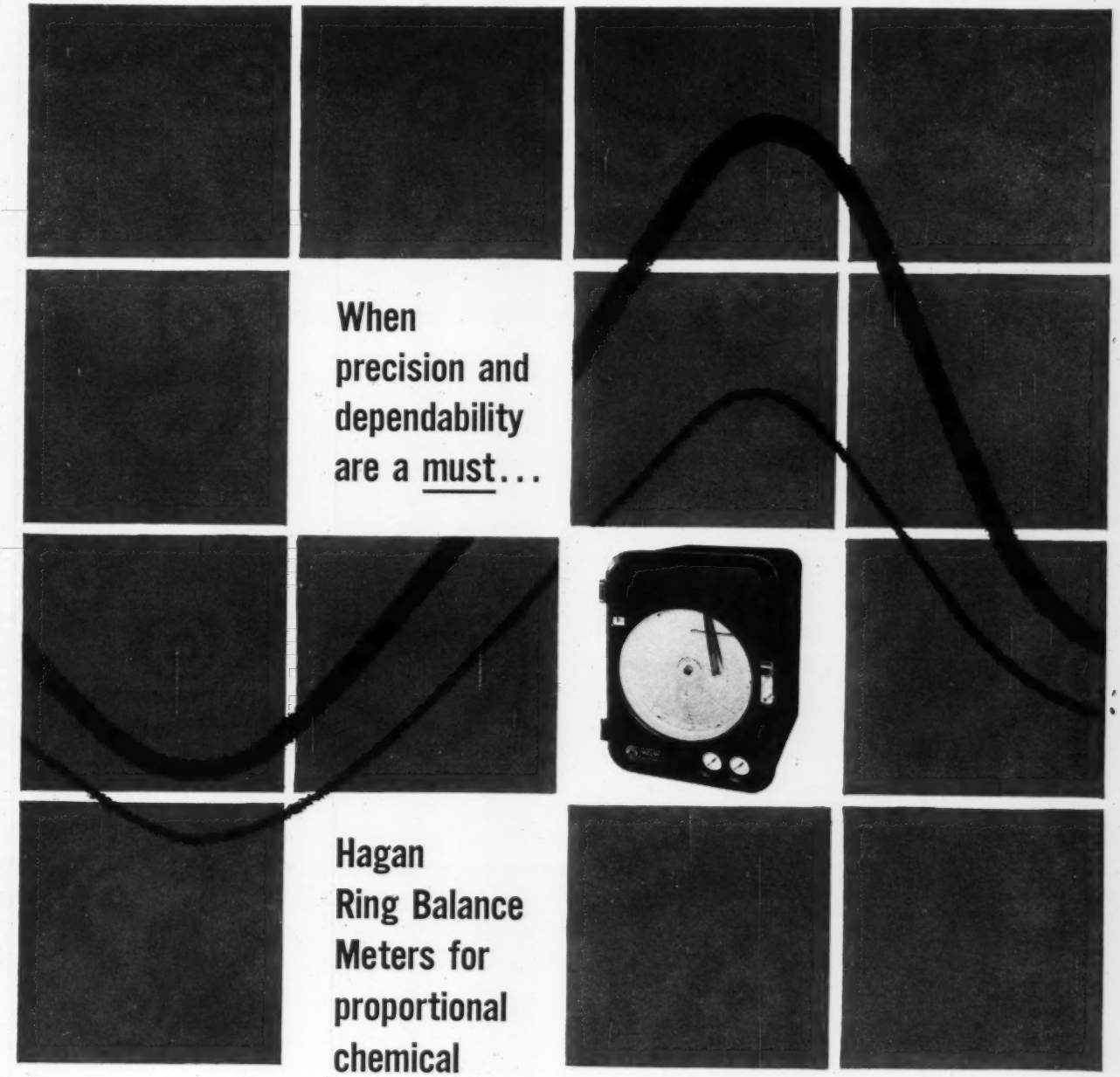

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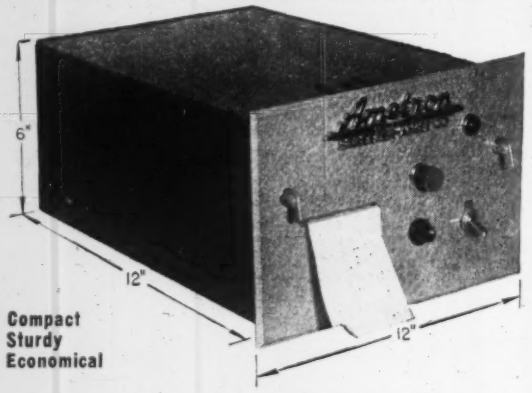

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BRIEFS —CONTINUED

rectangular hysteresis loop. High flux densities with low losses result in high efficiency cores. (*From new 16-page Bulletin WC-353, including magnetization and hysteresis loops, Thomas & Skinner Steel Products Co., Inc., Indianapolis 7, Ind.*)

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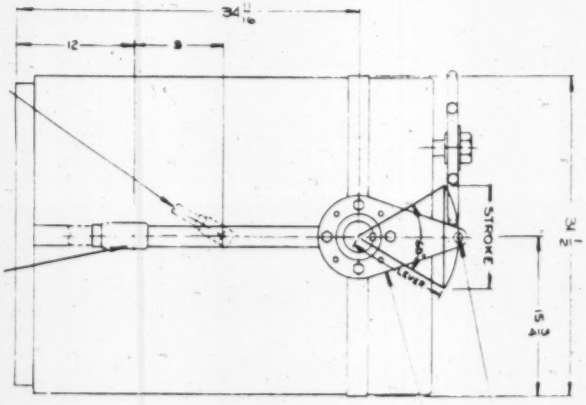
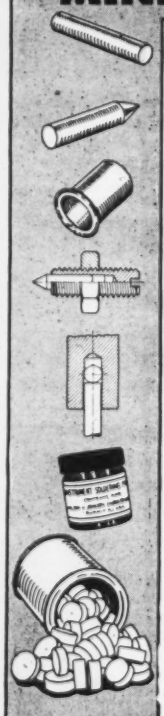


MINIATURE PARTS



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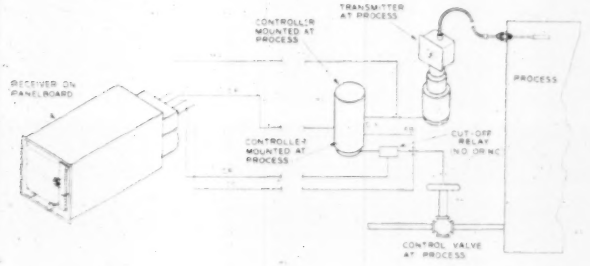
(From new 4-page Folio S-19, Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago 47, Ill.)

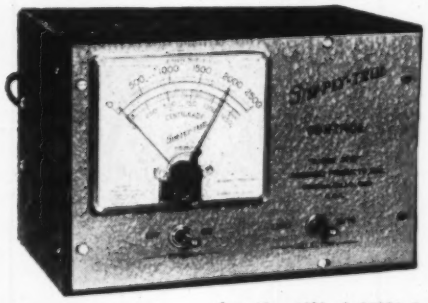
For this literature circle **505** on inquiry card.

Coordinated Process Control

With the Bristol system of Coordinated Process Control it is now practical to automatically control and operate



SIMPLYTROL AUTOMATIC PYROMETER



10 temperature ranges cover from -75° to 3000°F.

Several special ranges to -400°F.

Cat. No. 4531 0 2500° F.
Price $132.00

Thermocouple type Automatic Pyrometer for controlling temperature in furnaces, ovens, and processes. The Simplytrol is economical and reliable with few moving parts. There are no vacuum tubes. The regular load relay is S.P.D.T. 5 Amps. Optional heavy duty relays to 40 Amps.

10 temperature ranges cover from —75° to 3000° F. Several special ranges to —400° F. "On & Off" control for holding the desired temperature works on gas, oil or electric heat. Indicating meter-relay is medium high resistance and has bimetal cold junction compensation. For use with all standard thermocouples. Accuracy 2%.

"Auto-Limit" switch changes Simplytrol from automatic controller to limit pyrometer for safety shut down or warning. Cabinet: 6½x6½x9½ inches. Also flush panel mount models. Send for new Bulletin G-7 for more data. Assembly Products, Inc., Chesterland 10, Ohio.

Booth 311, I.R.E. Show, March 21-24

For more information circle **87** on inquiry card.

throw out obsolete testing

Cut Production Rejects and Re-work as much as 47%
Streamline Preventive Maintenance
Speed Up Trouble Shooting
with Triplett Model 630

Streamline Volt-Ohm-Mil-Ammeter—quick, accurate checks on voltage, current and resistance

Uses minimum bench space—3-7/32" x 5-1/2"—only 4 lbs.—completely portable for all preventive maintenance and electrical trouble shooting—laboratory instrument precision

Operation is completely streamlined—one switch for both circuit and range selection

630 VOLT-OHM-MIL-AMMETER

$39.50 net

33 RANGES

D.C. VOLTS:
0-3-12-60-300-1200-6000, at 20,000 Ohms/Volt. (For greater accuracy on TV and other High Resistance Circuits.)

A.C. VOLTS:
0-3-12-60-300-1200-6000, at 5,000 Ohms/Volt. (For greater accuracy in Audio and other High Impedance A.C. Circuits.)

D.C. MICROAMPERES:
0-60, at 250 M.V.

D.C. MILLIAMPERES:
0-1.2-12-120, at 250 M.V.

D.C. AMPERES:
0-12, at 250 M.V.

D.B.:
—30, +4, +16, +30, +44, +56, +70. (For Direct Reading of Output Levels.)

*OHMS:
0-1000-10,000 (4.4-44 center scale).

*MEGOHMS:
0-1-100 (4400-440,000 Ohms center scale).

TRIPLETT
ELECTRICAL INSTRUMENT COMPANY
Bluffton, Ohio

For more information circle **88** on inquiry card.

COMPRESSED AIR AND GAS COME OUT OF THE LOGAN ARIDIFIER

Scrubbed CLEAN AND DRY

INSTALL ARIDIFIERS ON LINES SERVING

- Paint Spray Guns
- Air Tools
- Air Hoists
- Foundry Jolting Machines
- Sand Blasting Tools
- Sand Blasting Rooms
- Metal Spray Guns . . . or Wherever the line must deliver clean, dry air or gas

On any air or gas line 92% of the dirt, oil, scale and water that enter the Aridifier is trapped and removed from circulation. The Aridifier's patented centrifugal-baffle action scrubs air and gas clean and dry . . . protects equipment, prevents freezing, fouling, corrosion and caking, produces best results with spray gun and air tool operations, etc. Easy to install. Self cleaning. Maintains itself. 10 models available. Capacity 7 CFM to 17,000 CFM.

Learn HOW the Aridifier scrubs with a patented centrifugal-baffle action.

Write for This Catalog

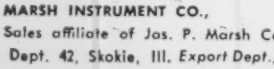
Now!

Logan ENGINEERING CO.
4921 W. Lawrence Ave., Chicago 30, Ill.

For more information circle **89** on inquiry card.

MARSH MAKES IT!

If it's a pressure gauge or dial thermometer, Marsh makes it . . . and makes it better. The types, ranges and case styles are endless. What is "special" to other instrument makers is often standard to Marsh. To know the scope of Marsh instruments—



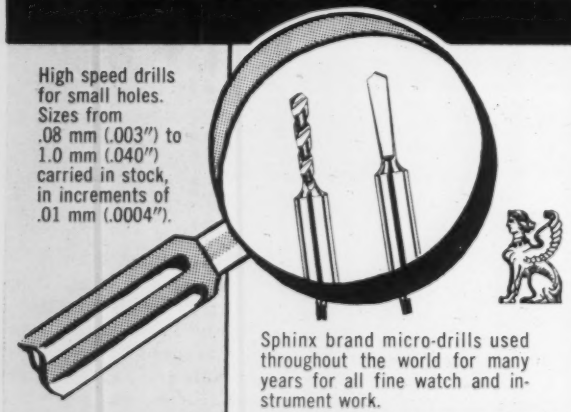
Write for this fact-filled catalog

MARSH INSTRUMENT CO.,
Sales affiliate of Jas. P. Marsh Corporation,
Dept. 42, Skokie, Ill. *Export Dept.*, 3501 Howard St., Skokie, Ill.

For more information circle **90** on inquiry card.

"IN-STOCK" SERVICE ON FAMOUS SPHINX BRAND MICRO-DRILLS

High speed drills for small holes. Sizes from .08 mm (.003") to 1.0 mm (.040") carried in stock, in increments of .01 mm (.0004").



Sphinx brand micro-drills used throughout the world for many years for all fine watch and instrument work.

Send for Bulletin N listing sizes and prices of stock drill sizes and micro-drilling equipment.

These precision drills are available in two styles, flat pivot drills or spiral fluted drills. They are made with concentric oversize shanks. Because of their rigidity they are especially useful in all types of drilling equipment.

JEVIN ® Louis Levin & Son, Inc.
3610 South Broadway · Los Angeles 7, California

For more information circle **91** on inquiry card.

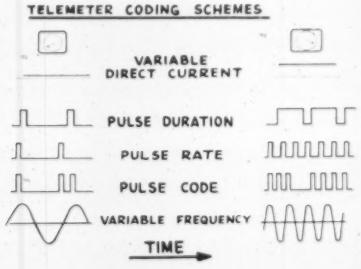
BRIEFS—CONTINUED

a whole industrial process . . . . operation of plants where entire processes are under the 100 percent automatic control of the Coordinated Process Control System represents instrument application in its most advanced form. (*From new 8-page folder Bulletin DM305, covering complete line of controllers, recorders, and telemeters, The Bristol Co., Waterbury 20, Conn.*)

For this literature circle **506** on inquiry card.

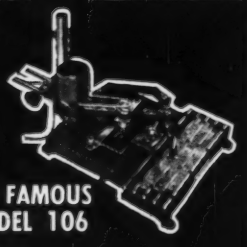
Selective Telemetering

Certain telemetered data must, of necessity, be continuously received. Furthermore, only a minimum delay is acceptable in its full and final presentation. Channels for these signals are best provided by multiplexing the communication media established between the control point and the remote station. However, other data is needed only at the operator's request. These may be periodic readings for log records, for investigations following various alarms,



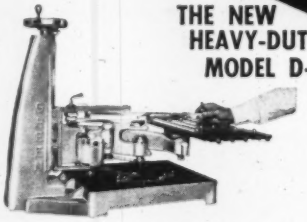
unique in design — rugged in construction

GREEN PANTOGRAPH ENGRAVERS



THE FAMOUS MODEL 106

THE NEW HEAVY-DUTY MODEL D-2



The three-dimensional bench Model 106 cuts costs — engraves, routs, models and profiles, giving you expert results even by unskilled workers.

The Model D-2 two dimensional heavy-duty Pantograph is a precision machine with a multitude of new features. Open on three sides, it permits complete freedom for engraving, milling, profiling large panels (up to 30" in diameter) or bulky pieces. Single, micrometer adjustment controls vertical depth of cut, automatically adjusting copy table with pantograph. Range of reduction ratios from 2-to-1 to infinity! Vertical range over 10 inches!

For complete information, write to

GREEN INSTRUMENT COMPANY
383 Putnam Ave. Cambridge, Mass.

For more information circle **92** on inquiry card.

or for information to permit adjustments to be made. Such data is best provided by selective telemetering or interrogative measurement. . . . Interrogative measurement systems usually use telemetering coding of the pulse code type. The measurement may be received on indicating dials, a cyclometer counter, or by teletypewriter presentation. (*From 14-page brochure ATIC-929-RS, Motorola, Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.*)

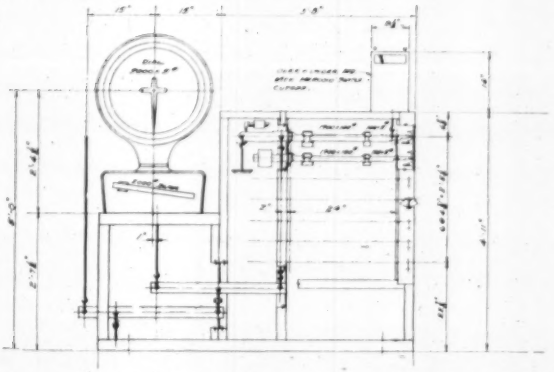
For this literature circle **507** on inquiry card.

Suspension Hopper Scales

Howe Suspension Hopper Scales are available in a wide range of sizes and capacities, from 500 to 120,000 pounds. They are furnished to accommodate any size or shape of hopper— for square, rectangular or cylindrical hoppers

Beams determine individual batches

- Dial indicates cumulative weight



Fine quality Gears can now be STAMPED by Winzeler, with a degree of *uniform* accuracy you never thought possible! That's why they are used so successfully in many unusual applications. Extremely skillful tooling, stamping and assembling by staking, brazing or riveting performed with speed and low cost efficiency in production runs only! Stock and custom dies. Ask our capable engineers for ideas and cost estimates.

SEND FOR *4-page folder containing valuable Stamped Gear data and tables. Write today!*

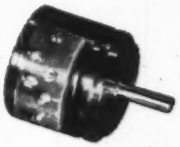
WINZELER *Stamped Gears*

WINZELER MANUFACTURING & TOOL CO.
1712 WEST ARCADE PLACE, CHICAGO 12, ILLINOIS

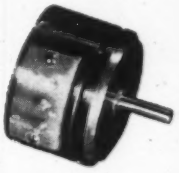
For more information circle **94** on inquiry card.

DATA SHEET

FAIRCHILD PRECISION POTENTIOMETERS



TYPE 751
⅞"



TYPE 741
1⅛"

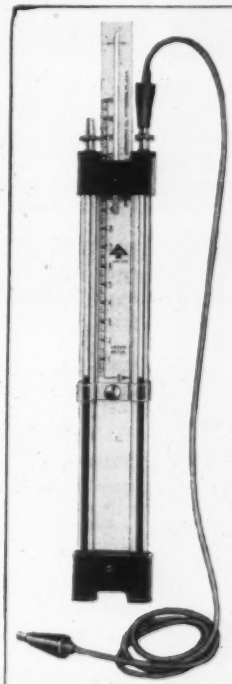
Miniature Single Turn Pots linear and nonlinear

Precision performance in linear or nonlinear functions is assured with these Fairchild miniature pots. The Type 751 (⅞" dia.,—weight 13 grams) has a resistance range up to 75,000 ohms. The Type 741 (1⅛" dia.,—weight 20 grams) has a resistance range up to 100,000 ohms. 0.5% standard accuracy, 0.25% special accuracy available. Terminals are gold-plated for reduced contact resistance and easier soldering.

SAMPLES AVAILABLE ON ORDER

These units show how Fairchild can help you solve all your precision potentiometer problems. For more information write Fairchild Camera & Instrument Corporation, Potentiometer Division, 225 Park Avenue, Hicksville, L. I., N. Y., Department 140-60B.

For more information circle **93** on inquiry card.



Gauge supplied with 4 ft. rubber hose and fitting for test connection.

Gauge with scale 0-7" W
$12.40

Gauge with reversible scale — 0-15" W on one side, and 0-8.5 ounces per sq. in. on other side.
$15.80

BACHARACH
Manometer

- Body is transparent, high-strength plastic extrusion.
- Scale features easy readability; made of white plastic, with black scale divisions and numerals; 1/10" W scale divisions.
- Indicating Fluid of 1.9 specific gravity permits pressure readings to 1/10" W over entire scale on gauge of convenient size. Fluid is colored blue for visibility; is non-freezing to low temperature. Gauge is furnished filled ready for use.
- Shut-off Valves are conveniently opened or closed by rotation of knurled discs.
- Scale is adjustable up or down to permit direct reading of pressure.
- Blow-over seal automatically prevents spilling of fluid when gauge is subjected to pressure surges in excess of scale range.
- Body serves as reel for rubber hose.
- For convenient attachment of gauge to pipe an adjustable mounting clamp is available as optional accessory.

Write for Leaflet 830

BACHARACH INDUSTRIAL INSTRUMENT COMPANY
7301 Penn Avenue, Pittsburgh 8, Pa.

For more information circle **95** on inquiry card.

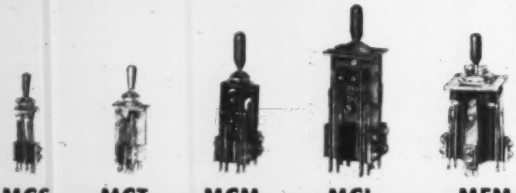
Type MCM Lever Switch

MCM

All lever combinations available. Four contact quadrants. Variety of circuits permitted. Ball-bearing lever action is smooth and positive. 5 amp. contacts are mounted on an easily removed contact block. Single-hole mounting.

Write for Bulletin CL-100

All General Control switches feature riveted coin silver or palladium alloy contacts and are individually adjusted and inspected. Switch types are available from 1 to 10 amperes.
Also available are special switches and contact assemblies to customer specifications.



MCS MCT MCM MCL MFM

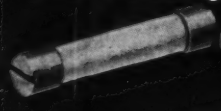
FOOT, LEVER, PUSH BUTTON and LIMIT SWITCHES
ELECTRONIC and SYNCHRONOUS–MOTOR TIMERS
CUSTOM CONTROL PANELS

GENERAL CONTROL COMPANY
1205 Soldiers Field Road • • Boston 34, Massachusetts

For more information circle **96** on inquiry card.

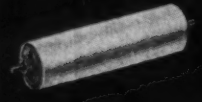
INTERNATIONAL

HIGH VOLTAGE *Selenium Rectifier* CARTRIDGES



FERRULE TERMINAL • phenolic tubing

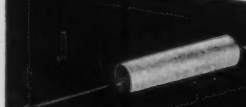
the WIDEST RANGE in the INDUSTRY



STUD TERMINAL • phenolic tubing

SPECIFICATIONS

DC output voltages from 20 to 20,000 volts and up.
DC output current, half wave from .2 MA to 195 MA. Cell diameters from 1/16" to 1" Cartridge lengths from 1/2" to 12"



PIGTAIL TERMINAL • phenolic tubing

APPLICATIONS

Computors, geiger counters, guided missiles radar circuits, oscilloscopes
Hermetically sealed units available for airborne applications.

Write for Bulletin H-2.

INTERNATIONAL
RECTIFIER CORPORATION
EL SEGUNDO, CALIFORNIA • ORegon 8-6281
NEW YORK: 501 MADISON AVENUE • Plaza 3-4942
CHICAGO: 205 W. WACKER DR. • FRanklin 2-3883

For more information circle **97** on inquiry card.

BRIEFS—CONTINUED

suspended horizontally or for cylindrical hoppers suspended vertically.

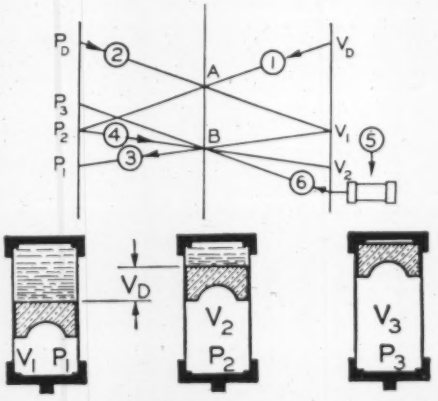
They can be installed in stationary position or incorporated into traveling larries or charging cars; or otherwise into special and original equipment.

Specific uses include: Weighing, proportioning and checking all kinds of blends and batches in the process industries. . . . Howe uses its renowned and proven pipe lever system for Hopper Scale use. (*From new 12-page Form 667, The Howe Scale Co., Rutland, Vt.*)

For this literature circle **508** on inquiry card.

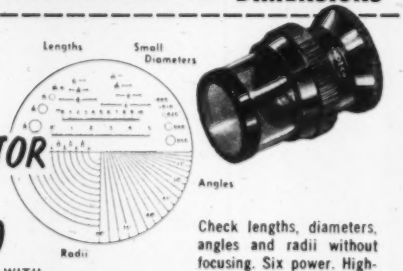
Accumulator Nomographs

Piston type accumulators for hydraulic systems are used principally for storage of hydraulic oil under pressure for actuation of hydraulic devices. Thus, accumulator furnishes



MAKE QUICK, ACCURATE MEASUREMENTS OF SMALL DIMENSIONS

INDECO *POCKET COMPARATOR*



Only **$22.50**

POSTPAID COMPLETE WITH GENUINE PIGSKIN CASE.

Check lengths, diameters, angles and radii without focusing. Highest quality, lowest price. Guaranteed accurate.

INDECO *MEASURING MICROSCOPE*

This 50 power pen-size measuring microscope permits measurements up to 1/10" by .001" divisions. Estimates to .0005" can be easily made.

Only **$7.95** POSTPAID

No focusing. Lensic reflector increases illumination of field. Precise but rugged.

15-DAY FREE TRIAL. ORDER TODAY DIRECT OR SEND FOR COMPLETE INFORMATION.

INDECO **INTERNATIONAL DEVELOPMENT COMPANY**
1 South Reed Street, East Riverton, N.J.
DEALERS INQUIRIES INVITED

For more information circle **98** on inquiry card.

hydraulic power at extremely high oil flow for relatively short cycles of operation intermittently.

Use the following six steps on nomograph to select smallest accumulator for a given system. (*From new 6-page Catalog File* 1536A10, *Ind. Hyd. Div., The Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*)

For this literature circle **509** on inquiry card.

Roller Gear Drives

Ferguson Roller Gear Drives represent the ultimate in cam indexing, using a precision worm-type cam drive and ball-bearing follower . . . The drive is a precision indexing mechanism. The accuracy of its index is as dependable as that of the most precise jig borer. We guarantee accuracy of plus or minus .001 inch at the pitch diameter of the followers. There is no backlash even at highest speeds . . . over 1000 indexes per minute in some instances. (*From new* 24-*page catalog* 105, *Ferguson Machine & Tool Co., Inc., P. O. Box* 191, *St. Louis* 21, *Mo.*)

For this literature circle **510** on inquiry card.

Air-cylinder Speed Control

The Bellows Electroaire Valve is a compact, air-operated, electrically triggered four-way air valve complete with built-in speed controls for adjusting air cylinder piston rod speed in either or both directions. Bellows "BEM" Series Air Motors are equipped with integral Electroaire Valves which are also available for remote

Designed for portability and low-cost as well as accuracy, the newly developed DS-660 will count and display any electrical or mechanical event which can be converted into a varying voltage of sufficient amptitude — from 10 to 100,000 events per second. Derives its time base from the 60 cycle line — which determines the accuracy — approximately .1%. Here is new and amazing reliability and circuitry available in one unit.

FEATURES:

SELF CHECKING

AUTOMATIC and MANUAL RESET

DISPLAY from 1 to 10 SECONDS

LIGHTWEIGHT — only 16 lbs.

UTILIZES STANDARD PLUG-IN DECADES

BASIC UNIT READS OUT TO 10 KC (4 decades)

AIR COOLED (Fan)

Write TODAY for full technical information

THE Detectron CORPORATION, Dept. 80-C
5528 VINELAND AVE., NORTH HOLLYWOOD, CALIF.

For more information circle **99** on inquiry card.

Surface
PYROMETERS
for every purpose

The routine use of CAMBRIDGE Surface Pyrometers takes the guesswork out of temperature determination in many industries. The CAMBRIDGE is accurate, dependable, rugged, quick-acting and easy to use. The Roll Model is for checking surface temperatures of moving rolls. The Needle Model is for insertion into materials in a plastic or semi-plastic state for batch temperature determination. The Mold Model is for checking surface temperatures of mold cavities and surfaces of almost any contour.

Send for Bulletin 194SA.

CAMBRIDGE INSTRUMENT CO., INC.
3742 Grand Central Terminal
New York 17, N. Y.

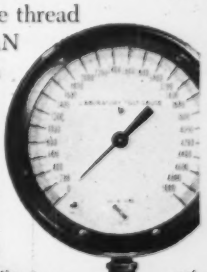
CAMBRIDGE
PIONEER MANUFACTURERS OF
PRECISION INSTRUMENTS

Moisture Indicators and Recorders • Physical Testing Instruments Laboratory Instruments for A.C. and D.C. • Galvanometers • Engineering Instruments • Gas Analysis Equipment • Physiological Instruments and many other Mechanical and Electrical Instruments

For more information circle **100** on inquiry card.

PROTECT
EXPENSIVE GAGES

SPRAGUE SHUT OFF VALVES automatically cut out gages and other pressure-sensitive instruments when fluid pressures go beyond their operating limits. Automatically open when pressure is again within approx. 80% of set cut-out points. Available for any pressure setting between 10 PSI. and 5000 PSI. Save valuable man hours. Eliminate opening and closing manually operated shut off valves. Supplied with standard pipe thread connections, also available with AN tube fittings. Body is 1½" aluminum hexagon stock. Length 5½". Bronze or stainless steel bodies also available. Easy to install. Thousands in use. Write for bulletin.



SPRAGUE
Engineering Corporation
1144 WEST 135TH STREET, GARDENA, CALIFORNIA

For more information circle **101** on inquiry card.

Check Temperatures Instantly... Accurately with Alnor TYPE 1500 PORTABLE PYROMETER

Wherever temperature readings are required—on the production line, in the laboratory or in the field—this sturdy precision instrument can bring you instant, accurate results.

Here's Why

It's Fast . . . in operation and quickly read. Precision movement designed to laboratory standards. Direct reading scale face is easily understood—no slide wires or conversion tables necessary.

It's Accurate . . . consistently to within ¾ of one percent under almost all variable conditions. Sturdy, protective case assures continued accuracy in toughest portable service. Ten scale ranges available, from 0-400° to 0-3000°F. Equivalent Centigrade scales available at no extra cost.

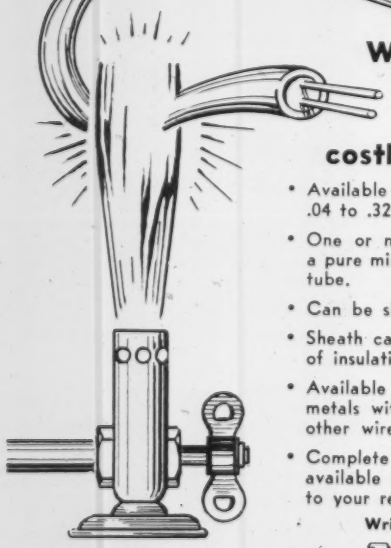
It's Portable . . . compact size, 6½"x6"x3", and light weight make this pyrometer highly portable and easy to use anywhere. Write today for complete details and prices. Illinois Testing Laboratories, Inc., Room 518, 420 N. La Salle Street, Chicago 10, Illinois.

Send for Bulletin on 1500 Pyrometer.

Alnor PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **102** on inquiry card.

INSULATED WIRE that will withstand 2000°F



Will last forever in service—eliminating costly replacement.

- Available in outside diameters of .04 to .32
- One or more wires insulated with a pure mineral swaged into a metal tube.
- Can be sharply bent.
- Sheath can be welded without loss of insulation.
- Available in a variety of sheath metals with thermocouples and other wire materials.
- Complete thermocouple probes available using this material made to your requirements.

Write for Bulletin 6A

aero research INSTRUMENT COMPANY, INC.

1901 NORTH HERMITAGE AVENUE CHICAGO 22, ILLINOIS

New York, Philadelphia, Detroit, Dallas, Los Angeles, San Francisco and Seattle

For more information circle **103** on inquiry card.

control of Bellows air motors, air cylinders, or other air powered devices. (*From new 28-page Bulletin SP-50 "Air Motors and Valves," The Bellows Co., 222 W. Market St., Akron, Ohio.*)

For this literature circle **511** on inquiry card.

Temperature Handbook

There are 8 ways of responding to temperature—1) changes in pressure, 2) changes in liquid volume, 3) ex-

Response To Temperature	Temperature Range Of Application Deg. F
Changes in Pressure	
Kerosene Filled	250-700
Alcohol Filled	200-400
Ether Filled	100-300
Sulfur Dioxide Filled	20-250
Nitrogen Filled	0-500
Changes in Liquid Volume	
Mercury Filled (Steel Bulb-Capillary)	—20-1200
Mercury Filled (Ordinary)	— 4-680
Mercury Filled (Nitrogen Covered)	—38-1000
Alcohol Filled	—50-300
Glycerine Filled	30-500
Differences in Expansion of Metals	
Bimetallic Strips	0-700
Bimetallic Rods	300-1000
Changes in Electrical Resistance	
Electrical Resistance Thermometer	—400-1800
Thermocouples	
Base Metal (Copper-Constantan)	50-660
Base Metal (Iron-Constantan)	100-1650
Base Metal (Chromel-Alumel)	300-2000
Rare Metal (Platinum-Rhodium)	300-2800
Photo-Electric Effects	
Radiation Pyrometer	1000 up
Changes in Color	
Optical Pyrometer	1400 up
Changes in Melting Points	
Fusion Pyrometers	1100-3600

AGASTAT

Compact . . . Dust-Proof

TIME DELAY RELAYS

solenoid actuated—pneumatically timed

Introduces time delays into a-c or d-c circuits. Easily adjusted to provide delays ranging from 0.1 second to five or more minutes.

The AGASTAT is small, light, and operates in any position. Dust-proof timing chamber assures long operating life with a minimum of maintenance.

AGA DIVISION

Elastic Stop Nut Corporation of America

1027 Newark Avenue, Elizabeth, New Jersey

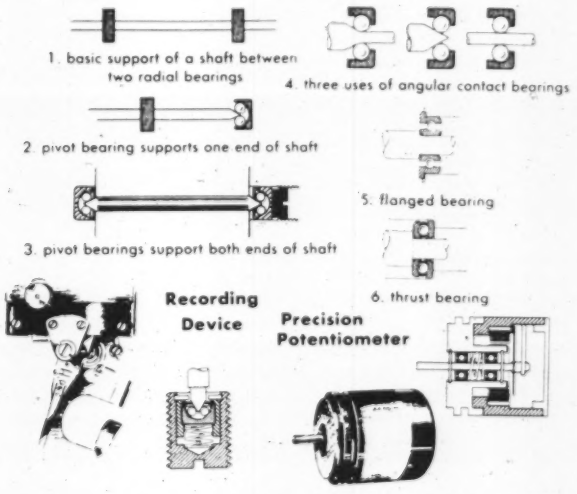
Dept. A 15-29

For more information circle **104** on inquiry card.

pansion of metals, 4) changes in electrical resistance, 5) thermocouples, 6) photoelectric effects, 7) changes in color, 8) changes in melting point. (*From new 24-page Bulletin 101, "The Guide," The Partlow Corp., New Hartford, N. Y.*)

For this literature circle **512** on inquiry card.

Miniature Bearings


1. basic support of a shaft between two radial bearings
4. three uses of angular contact bearings
2. pivot bearing supports one end of shaft
5. flanged bearing
3. pivot bearings support both ends of shaft
6. thrust bearing
Recording Device
Precision Potentiometer

Typical methods of using miniature bearings: (*From new 20-page Form 53-54, Miniature Precision Bearings, Inc., Keene, N. H.*)

For this literature circle **513** on inquiry card.

BARBER COLMAN

Barcol

Small Motors

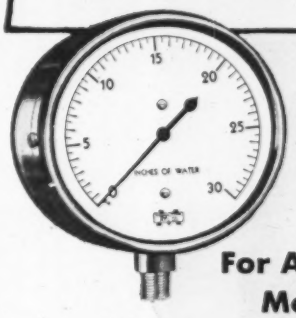
keep charts taut on Aerovane Recorders by Bendix-Friez

As both an indicating and recording instrument, the Bendix-Friez Aerovane Recorder plots each wind speed and position change on a continuous strip chart. A Barber-Colman KYAB motor is used as a constant take-up to keep the chart stretched taut across the points at which recording pens meet the paper. For precise operation of your instruments, too, there's a wide line of high-torque Barcol Small Motors . . . unidirectional, synchronous, and reversible . . . with or without reduction gearing . . . up to 1/20 hp. Write for data sheets.

BARBER-COLMAN COMPANY, Dept. N, 1215 Rock St., Rockford, Ill.

For more information circle **105** on inquiry card.

MARSHALLTOWN



DIAPHRAGM GAUGE

For Accurate Pressure Measurement in Ounces or Inches of Water

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Write for details and price.
LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MANUFACTURING CO.
MARSHALLTOWN 3, IOWA

For more information circle **106** on inquiry card.

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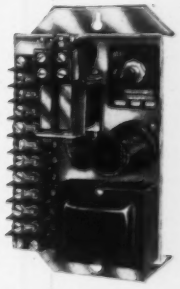
trigger action

independent of voltage fluctuations

12.5 amp. capacity
at 115-v. a-c non-inductive load



atc®

ELECTRONIC CONTACTORS

The supersensitive probe circuit with the hot-cathode thyratron assures positive, no chatter firing. Invaluable in motion-limit control down to micro-inches; tear or breakage detection and automatic feed cut-off in production processes; motor or valve actuation in photo-cell circuits; liquid-level control —countless other automatic control uses.

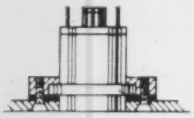
A rugged low-voltage control circuit contactor, normally fired or normally unfired. Write for Bulletin H-20, giving full information.
Automatic Temperature Control Co., Inc.
5224 Pulaski Ave., Philadelphia 44, Pa.

Represented in Canada by: Powerlite Devices, Ltd., Toronto, Montreal and Vancouver

For more information circle **107** on inquiry card.

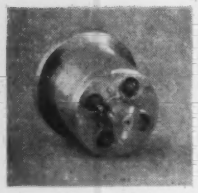
new accuracy for dynamic pressure measurement

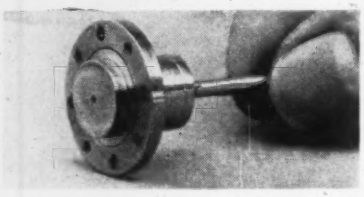
Offered in absolute, differential, or gage models, CEC's new Type 4-312 Pressure Pickup brings a new standard of accuracy to dynamic pressure measurement. Flush-diaphragm design and extremely small size . . . only ½"-diameter . . . make the 4-312 ideal for flush mounting in airfoils and other aerodynamic surfaces for both wind-tunnel and flight tests . . . in hydrodynamic test hulls for tow-tank studies . . . and in valves and venturis for pressure-drop measurement. Response to vibration and shock or static acceleration is negligible. Write for your copy of Bulletin CEC-1540



Typical Mounting—Flange Installation

RANGES: absolute and gage, 10 to 150 psi; differential, ±5 to ±75 psid . . . **EXCITATION:** 5 volts a-c or d-c . . . **BRIDGE IMPEDANCE:** 350 ohms . . . **SENSITIVITY:** 4.0 mv per volt of excitation, full scale . . . **TEMPERATURE RANGE:** −65°F to +250°F . . . **HYSTERESIS and LINEARITY DEVIATION:** less than 0.75% of f.s. . . . **SIZE:** ½" diameter by ¾" length . . . **DIAPHRAGM MOUNTS FLUSH** . . . mounting rings furnished . . . adapters available for pipe connection.





Differential pickups have tube for reference pressure connection; gage models have relief port; absolute models are hermetically sealed; connections on all models are through 4 numbered pins.

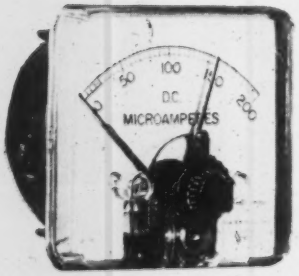
Consolidated Engineering CORPORATION

300 North Sierra Madre Villa, Pasadena 15, California

For more information circle **108** on inquiry card.

METER-RELAYS

For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases).

Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland **10**, Ohio.

Booth 311, I.R.E. Show, March 21-24

For more information circle **109** on inquiry card.

Test Your I. Q. (Instrument

Question 1

Ideally perfect closed-loop response would be
(a) infinite gain, zero phase shift
(b) unity gain, zero phase shift
(c) infinite gain, 180-degree phase shift
(d) unity gain, 180-degree phase shift

Question 2

Ideally perfect open-loop response would be
(a) infinite gain, zero phase shift
(b) unity gain, zero phase shift
(c) infinite gain, 180-degree phase shift
(d) unity gain, 180-degree phase shift

Question 3

A gain of one (unity) expressed in decibels is
(a) minus 1 db
(b) zero db
(c) plus 1 db
(d) plus 10 db

Question 4

A system becomes unstable when
(a) open-loop gain is unity and phase lag is zero
(b) closed-loop gain is unity and phase lag is zero
(c) open-loop gain is unity and phase lag is 180 deg.
(d) closed-loop gain is unity and phase lag is 180 deg.

Question 5

Allowing a phase margin of 45 degrees, the phase margin criterion of stability becomes
(a) unity gain at the frequency where the phase shift is 135 degrees
(b) unity gain at the frequency where the phase shift is 180 degrees
(c) minus 8 db gain at the frequency where the phase shift is 135 degrees
(d) minus 8 db gain at the frequency where the phase shift is 180 degrees

Question 6

Allowing a gain margin of 8 db, the gain margin criterion of stability becomes
(a) unity gain where the phase lag is 135 degrees
(b) unity gain where the phase lag is 180 degrees
(c) minus 8 db gain where the phase lag is 135 degrees
(d) minus 8 db gain where the phase lag is 180 degrees

Question 7

On Bode diagrams, gains are plotted in db in order to
(a) cover a wide frequency
(b) linearize the curves
(c) totalize elements in series
(d) do all the above

Question 8

In db (20 log amplitude ratio) a simple first-order system is characterized by an attenuation rate, above the cutoff frequency, of
(a) zero db
(b) 10 db per decade
(c) 20 db per decade
(d) 40 db per decade

Question 9

A second-order element attenuates at a rate of
(a) zero db
(b) 10 db per decade
(c) 20 db per decade
(d) 40 db per decade

Question 10

On a Bode diagram, changing the rate and reset response causes the curves on the diagram to
(a) remain stationary
(b) change slope
(c) move left or right
(d) move up or down

Question 11

Which of the following statements about the "ultimate period" (p_u) of a process is true?
(a) It is found by increasing the proportional gain until the process cycles.
(b) It is the duration of one cycle in minutes.
(c) It is used in determining the reset and rate settings.
(d) All the above are true

Question 12

A starved-current pentode is characterized by
(a) low screen voltage and high plate-load resistor
(b) high screen voltage and high plate-load resistor
(c) low screen voltage

and low plate-load resistor
(d) low plate-voltage supply

Question 13

Advantage of a starved-current amplifier is
(a) simple circuit
(b) high gain
(c) improved frequency response
(d) all the above

Question 14

Basic use of the "negative-inductance" circuit is
(a) reduction of time constant of inductive circuits
(b) oscillating element in oscillators
(c) high-impedance element in amplifiers
(d) all the above

Question 15

Phase-shift oscillators are characterized by
(a) simplicity and low distortion
(b) adjustable frequency
(c) three R-C L-section phase shifters
(d) all the above

Question 16

Which one of the following statements about a flip-flop circuit is NOT true?
(a) It is a bistable multivibrator.
(b) It is used for counting and frequency division.
(c) Both stages cut off simultaneously.
(d) Each grid is direct coupled to opposite plate.

Question 17

Advantage of a cathode-follower voltage divider over a bleeder-resistance divider is that the former
(a) is simpler
(b) loses less power
(c) provides variable output
(d) does all the above

Question 18

A phase-shift oscillator acts like a high-Q filter when
(a) a high-Q coil is used in plate circuit
(b) gain is reduced below oscillating point
(c) two phase-shift networks are used
(d) fed from a cathode follower

Question 19

The new feature introduced by the Mohr blast-furnace control system is
(a) control of furnace-charging program
(b) control of hot-blast temperature
(c) recording of stock-line and inwall temperatures
(d) all the above

Question 20

Advantage to use of oil rather than air in piston operators for valves (as in gas-regulating service) is
(a) simpler system can be used
(b) no pump is required
(c) less tendency to hunt
(d) all the above

Question 21

A pneumatic relay that is used to put a control valve under the control of either of two controllers having the higher output pressure is called
(a) a reversing relay
(b) a selective relay
(c) a snap-acting relay
(d) an averaging relay

Question 22

A pneumatic relay that is used to transform the output air pressure of a throttling-type controller to an on-off type air-pressure signal for a control valve is called
(a) a reversing relay
(b) a selective relay
(c) a snap-acting relay
(d) an averaging relay

Question 23

Which of the following statements about load-cell-type electronic weighing systems is NOT true?
(a) Load cells usually contain four strain gages
(b) The gages are arranged in a Wheatstone bridge circuit
(c) D-c. is preferred to a-c. energization
(d) Load cells are insensitive to lateral loads

Need instrument charts?

If you do, it makes sense to get them from a firm familiar with instrumentation problems. That's us.

We're not only instrument makers, we're one of the largest chart printers in the country – with 65 years of experience in printing precision instrument charts.

We've recently expanded our engineering and production facilities for printing recorder charts for other instrument companies to their specifications. Now we can supply circular charts up to 12 inches in diameter and strip charts up to 29¾ inches wide for all types of special instruments, including research, industrial, test, analytical, scientific, laboratory and pilot plant instruments and computers.

In addition, special papers for dry recording, such as wax coated, heat sensitive, chemically coated and electrically sensitive papers, can be handled on our new equipment.

Our engineering service has also been expanded to help instrument builders develop charts best suited for their particular needs.

Write for free bulletin describing and picturing our chart production facilities. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

4.17

BRISTOL

Points the Way in Human-Engineered Instrumentation

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **110** on inquiry card.

New Literature...

INSTRUMENTS and AUTOMATION

AUTOMATION

Progress Report for 1954. New 64-page issue of "General Electric Review, Jan. 1955" (Vol. 58, No. 1) features progress report on 1954 developments in research, nucleonics, testing and measuring, power, industry, rail, aviation, accounting, electronics, lighting, air conditioning, building construction, etc.—General Electric Co., Schenectady 5, N. Y.

Circle **514** on inquiry card.

Electric Proportioning Controller. New 16-page Folder NDA 7a describes maker's new "Series 60" electric proportioning control system. Includes circuits for position-adjusting and duration-adjusting control actions.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

Circle **515** on inquiry card.

Process Control Instruments. New 4-page Bulletin GL-1 describes maker's indicating, recording and controlling instruments which include dial thermometers, pressure and temperature recorders. 4-page Bulletin P-1 describes pressure pilot for accurate responsive control.—United States Gauge Div., American Machine and Metals, Inc., Sellersville, Pa.

Circle **516** on inquiry card.

Temperature Control. New 2-page Application Engineering Data Sheet AED 320-10 describes maker's instrumentation system for precision temperature control of glass feeders.—Foxboro Co., Foxboro, Mass.

Circle **517** on inquiry card.

Hydraulic Surge Control. New 58-page manual "Analysis & Control of Hydraulic Surge" covers water hammer, surge suppressing devices, surge control with pneumatic suppressors, pulsation control and resonance, accumulators, and thermal expansion compensation.—Magnilastic Div., Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

Circle **518** on inquiry card.

Telemetering-Control System. New 8-page Bulletin 9100 describes maker's "Telestep" remote-transmission systems for water, sewage and process plant uses. Includes five basic models: 1-step, 2-step, 2-step with reporting signal, multiple-step (bridge-type) and proportional-multiple step.—Automatic Control Co., 1005 University Ave., St. Paul 4, Minn.

Circle **519** on inquiry card.

Meter-relay Controls. New 12-page Bulletin G-7 describes maker's "Sim-Ply-Trol" thermocouple pyrometer control for furnaces, ovens or industrial processes; and "Versatrol" automatic control responding to changes of current or voltage, either a-c. or d-c.—Assembly Products, Inc., Chesterland, Ohio.

Circle **520** on inquiry card.

Proportioning Control. New 4-page issue of "Wheelco Comments" (Vol. 14, No. 6) describes maker's "Model 405" proportional position controller used on continuous-process applications requiring proportional relationship between fuel input and a continuously-measured temperature.—Wheelco Instruments, Barber-Colman Co., Rockford, Ill.

Circle **521** on inquiry card.

Automation Study System. New 24-page booklet "More Dollars From Less Space" pictures and describes maker's work centers, parts, containers, conveyors, and fact finders for greater production, efficiency and flexibility.—Alden Systems Co., Washington St., Westboro, Mass.

Circle **522** on inquiry card.

Viscosity Control System. New 2-page Form VA-20 describes maker's viscosity control system for recording or recording-controlling of viscosity in industrial plants.—Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

Circle **523** on inquiry card.

Servo Multiplier. New 2-page bulletin describes maker's "Model SL-1053" servo multiplier driven by reversible polarity d-c.—Industrial Control Co., Wyandanch, L. I., N. Y.

Circle **524** on inquiry card.

Electromechanical Amplifier. New 4-page folder describes maker's electromechanical amplifier for controlling machines, mechanisms, and instruments where torque or a rotating device is employed as a source.—Electomic Designs, P. O. Box 1156, Greenwich, Conn.

Circle **525** on inquiry card.

Chlorinator Control. New 12-page Bulletin TA-1013-C 1 presents information on types of chlorinator control available and various problems giving proper controls for solving them.—Wallace & Tiernan, Newark 1, N. J.

Circle **526** on inquiry card.

Chlorinizers. New 4-page illustrated Bulletin 840-K13 describes maker's automatic pacing systems for chlorine feeding problems.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.

Circle **527** on inquiry card.

Light Controls. New 4-page Folder SE 115419 describes maker's "Luxtrol" light-control system "Type WBD360" for controlling light intensity of rapid-start fluorescent lamps.—Superior Electric Co., Bristol, Conn.

Circle **528** on inquiry card.

Servo Systems. New set of Bulletins FC1 describes and illustrates maker's standard servo systems and components, magnetic servo amplifiers, booster amplifiers, and universal operation and d-c. instrument servo amplifiers.—Feedback Control, Inc., 1332 N. Henry St., Alexandria, Va.

Circle **529** on inquiry card.

Quality Control. New 4-page issue of "Engineering News" (Vol. 1, No. 1) features article on "Statistical Quality Control In Precision Manufacture."—Miniature Precision Bearings, Inc., Keene, New Hampshire.

Circle **530** on inquiry card.

Combustion System Instrumentation. New 32-page Bulletin 1600-A describes and illustrates maker's oval observation ports, vertical check valves, tank name plates, levelometer gages, safety check valves, industrial thermometers, fuel oil filter, portable draft gages, etc.—Preferred Utilities Manufacturing Corp., 1860 Broadway, New York 23, N. Y.

Circle **531** on inquiry card.

Combustion Control System. New 16-page Bulletin CF-30 describes maker's "Fireye" combustion control system which provides complete automatic starting and operating flame-failure protection for oil, gas, and combination burners.—Combustion Control Div., Electronics Corp. of America, 718 Beacon St., Boston 15, Mass.

Circle **532** on inquiry card.

Index Tables. New 12-page Catalog 300 describes and illustrates maker's "Intermittor" standard precision index tables for high-speed production. Contains assembly drawings, tables of load ratings and dimensions of over 150 models.—Ferguson Machine & Tool Co., Roller Gear Div., P. O. Box 191, St. Louis 21, Mo.

Circle **533** on inquiry card.

Automatic Assembly Machines. New 6-page folder describes maker's fully automatic assembly machines for assembling of component parts.—Multra Corp., 30 Commerce Rd., Stamford, Conn.

Circle **534** on inquiry card.

Tower Lighting Control. New 2-page Bulletin HPS-135 describes maker's "Models LC 2072, LC 2073, and LC 2074" control units for standard tower lighting of various light-level categories.—Hughey & Phillips, Inc., 3300 N. San Fernando Blvd., Burbank, Calif.

Circle **535** on inquiry card.

Signalling Device. New 2-page bulletin describes maker's rotary indicator, a multi-purpose hand-reset signalling device for industrial and military applications.—Allard Instrument Corp., 30 Broad St., New York 4, N. Y.

Circle **536** on inquiry card.

VALVES

Valves. New illustrated 64-page Catalog 654 describes maker's needle, globe, plug, check, relief, selector, aviation, industrial and special valves for hydraulic, lubricating, fuel, steam, air and other fluid systems.—Republic Manufacturing Co., 15655 Brookpark Rd., Cleveland 11, Ohio.

Circle **537** on inquiry card.

Relief Valves. Two new Bulletins 1 and 2 describe maker's "Type FR" back-pressure relief valves for pressures from 0 to 400 psi. Includes capacity data table for determining correct size of valve.—A. W. Cash Valve Mfg. Co., 666 E. Wabash Ave., Decatur, Ill.

Circle **538** on inquiry card.

Air Valves. New 4-page booklet describes and illustrates maker's 3-way and 4-way "Airswitch" air valves designed for pipe thread connection to rear or side ports of cylinders.—Airelectric Corp., P. O. Box 208, Melrose Park, Ill.

Circle **539** on inquiry card.

Shutoff Valve. New 2-page Bulletin 200 describes maker's "Model 350" combination safety shutoff valve which eliminates danger of ruptured gasmeters, fires, and explosions resulting from excessive gas pressures.—Valco, Inc., 1410 W. Ave., Cincinnati 15, Ohio.

Circle **540** on inquiry card.

MOTORS, SERVOS

Servomotors, Control Transformers. New 24-page Catalog 155 describes and illustrates maker's low-inertia servo motors, precision-gearhead motors, control transformers, phase-angle measuring sets, etc.—Infra Electronic Corp., 553 Eagle Rock Ave., Roseland, N. J.

Circle **541** on inquiry card.

Synchronous Motors. New 8-page Brochure PB-110 presents description on maker's dual, clutch and standard motors for timing devices, power drives and signal systems.—R. W. Cramer Co., Inc., Centerbrook and Ballouville, Conn.

Circle **542** on inquiry card.

Motor Speed Control. New 8-page Brochure 875-A presents maker's large line of Variac motor speed controllers for control of d-c motors from a-c lines.—General Radio Co., Cambridge 39, Mass.

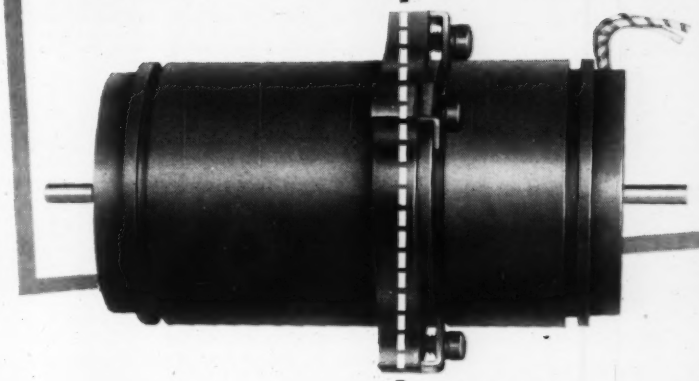
Circle **543** on inquiry card.

Servo Motors. New 12-page Booklet CDG 6046 describes maker's facilities for design, development, and manufacture of high-frequency rotary power supplies, motor-driven blowers and fans, fixed- or variable-frequency drive motors, a-c. industrial motors, miniature servomechanism components, 400-cycle ground power units and test stands.—American Electronic Mfg., Inc., 9503 W. Jefferson Blvd., Culver City, Calif.

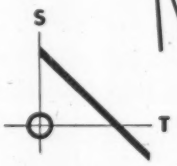
Circle **544** on inquiry card.

Aircraft Control Motors. New 38-page Catalog F 4344-1 describes maker's permanent-magnet d-c. motors

GEARED FOR
FAST RESPONSE



Gear Reducer + Instrument Servo Motor



Now! DIEHL offers this Instrument Servo Motor with a Gear Reducer attractively priced for commercial applications in five different ratios. Either the motor, gear reducer or both can be quickly replaced avoiding costly down-time. The spur gear construction insures good efficiency.

GEAR REDUCTION RATIOS	SERVO MOTOR SPECIFICATION		
	Output (Watts)	1	5
191.1	Frequency (Cycles)	60	60
79.6	Poles	2	2
32.4	Reference Phase (Volts)	115	115
13.8	Control Phase (Volts)	50	115
5.8	Reference Phase (Watts)	10	17
to 1	Control Phase (Watts)	3.5	17
	Control Phase Impedance (Ohms)	555	575

Our engineering staff will gladly help you select the motors best suited to your specific requirements. A request on your letterhead will bring you a copy of Technical Manual No. IN-0255 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl
DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO
Finderne Plant, SOMERVILLE, N. J

For more information circle **111** on inquiry card.

with outputs up to 1/10 hp. Includes data sheets on typical motors from 6 to 115 volts d-c, and describes units having radio-noise filters, gear heads, and centrifugal blowers.—Barber-Colman Co., Rockford, Ill.

Circle **545** on inquiry card.

POWER OPERATORS

Cylinder Motors. New 12-page Bulletin B-50-2 describes and illustrates maker's cylinder "Conomotor" pneumatically-positioned power operator for proportional control of speed changers, valves, pumps and electrical components.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

Circle **546** on inquiry card.

Long-Stroke Diaphragm. New 2-page catalog supplement (Form 200) describes and illustrates maker's flangeless, bead-type "Bellofram" long-stroke diaphragms. Designed for all pressure-sealing applications, these diaphragms convert pressure into a long stroke at high thrust levels without mechanical friction.—Bellofram Corp., 144 Moody St., Waltham, Mass.

Circle **547** on inquiry card.

Hydraulic Transmission. New 2-page Bulletin 47-40B describes maker's ¾-hp, variable-speed hydraulic transmission for industrial applications. Includes charts of output-speed ranges, drawings for handwheel-controlled and servo-controlled models.—Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.

Circle **548** on inquiry card.

Speed Variator. New 4-page Bulletin K-100 describes and illustrates maker's speed variator that provides variable output speed over a 9:1 range from a constant-speed power source.—Cleveland Worm and Gear Co., 3269 E. 80th St., Cleveland 4, Ohio.

Circle **549** on inquiry card.

TEMPERATURE

Millivoltmeter Pyrometers. New 12-page Bulletin P1244 describes and illustrates maker's millivoltmeter pyrometers, automatic controllers, indicating pyrometers, and pyrometer switches.—Bristol Co., Waterbury 20, Conn.

Circle **550** on inquiry card.

Temperature Control. New 4-page Data Sheet 644-1 describes maker's "Rayotube" detectors and "Speedomax" electronic recorders for control of glass feeder temperatures.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **551** on inquiry card.

Temperature Detectors. New 2-page Data Sheet N-S3 (1) describes maker's line of "Rayotube" radiation-type temperature detectors for measuring temperature of stationary or moving surfaces.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **552** on inquiry card.

Immersion Thermocouple. New 4-page process data sheet 643 (1) describes maker's immersion thermocouple for measuring bath temperatures on open hearths and electric furnaces on a full-time operating basis.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **553** on inquiry card.

Thermocouple-Air Converter. New 2-page Bulletin A-714 describes maker's "Type T3C" thermocouple-air converter that converts to output to pneumatic signal.—Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

Circle **554** on inquiry card.

Thermoregulator. New 2-page Bulletin 20 describes maker's signal-light thermoregulator and signal-light thermostat for controlling temperature of air or liquid.—Philadelphia Scientific Glass Co., 1866 Eckart Ave., Abington, Pa.

Circle **555** on inquiry card.

Temperature-system Tester. New 12-page Booklet 3M-754 describes maker's "Jetcal" jet-engine temperature-system tester for checking accuracy of thermocouple systems, and "Tempcal" probes (small temperature-sensitive element with built-in furnace for spot-heating) for checking thermal switches, over-heat detectors, etc.—B & H Instrument Co., Inc., 1009 Norwood, Fort Worth 7, Texas.

Circle **556** on inquiry card.

Indicating Temperature Controller. New 2-page Form 334 presents maker's expansion-type temperature controller with new feature—a bimetallic dial thermometer to indicate the controlled temperature.—Burling Instrument Co., 16 River Rd., Chatham, N. J.

Circle **557** on inquiry card.

Electric Ovens. New 8-page bulletin describes and illustrates maker's "Power-O-Matic" temperature-controlled electric ovens.—Boder Scientific Co., 719-721 Liberty Ave., Pgh. 22, Pa.

Circle **558** on inquiry card.

Woven Electric Heaters. New 4-page Bulletin F-1548 describes and illustrates maker's woven electric heaters used for heating liquids, instrument cases, etc.—Pre-Fab Heater Co., Guilford, Conn.

Circle **559** on inquiry card.

Laboratory Heater. New 4-page Brochure RS-2654-CT describes maker's "Multi-Block" heater for applications requiring controlled heat in laboratories.—Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.

Circle **560** on inquiry card.

Flexible Heating Elements. New 4-page folder describes maker's high-temperature electrical, silicone-rubber insulated flexible heating elements that can operate under high pneumatic pressures.—Electro-Flex Heat, Inc., 516 Asylum St., Hartford 5, Conn.

Circle **561** on inquiry card.

PRESSURE

Pressure Transducer. New 4-page Bulletin 625 describes maker's "Model EP" engine-pressure transducer for pressure measurements requiring high-frequency response and minimum changes in volume of pressure vessel.—Control Engineering Corp., Norwood, Mass.

Circle **562** on inquiry card.

Super-pressure Instrumentation. New 100-page Catalog 406 describes and illustrates maker's line of pumps, gages, control valves, reaction vessels, etc., for pressures up to 100,000 psi. and temperatures to and above 1000 deg. F.—American Instrument Co., Inc., Superpressure Div., Silver Spring, Md.

Circle **563** on inquiry card.

Pressure-tight Fittings. New 2-page bulletin describes and illustrates maker's "Flare-Matic" tubing fittings used with pneumatic and hydraulic tools and equipment, chemical and petroleum processing, instrumentation, etc.—Century Products, Inc., 315 S. 15th St., Phila. 2, Pa.

Circle **564** on inquiry card.

FLOW

Anemometers. Two new 2-page data sheets describe maker's line of hot-wire-constant-current anemometer equipment, and static-pressure probe "Model SSP-1" for measuring static-pressure in fluctuating air flow.—Flow Corp., 283 Concord Ave., Cambridge, Mass.

Circle **565** on inquiry card.

Controlled-Volume Pumps. New 2-page Data Sheet C-54-1 describes maker's controlled volume pumps for con-

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trolling low-capacity flows in continuous phosphatizing.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

Circle **566** on inquiry card.

Feed Pump. New 4-page Bulletin PM 20 describes and illustrates maker's "Model S" diaphragm feed pump for accurately feeding chemical solutions used in water works and industry.—Precision Chemical Pump Corp., 1396 Main St., Waltham 54, Mass.

Circle **567** on inquiry card.

Controlled Odorant-Injection System. New 2-page Application Engineering Data Sheet E-54-7 describes maker's automatically controlled pump system used on natural-gas pipelines to inject odorants into varying natural gas flow.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

Circle **568** on inquiry card.

LEVEL

Level Indicator. New 4-page bulletin describes maker's "Bin-Vue" level indicators for showing high and low levels of materials in bins, reactors, cyclones, conveyors, chutes, etc. Can be used on powdered, granular, lumpy and wet materials.—Convair, Pittsburgh, Pa.

Circle **569** on inquiry card.

RECORDERS

Oscillographs, Amplifiers. New 4-page folder describes maker's line of amplifiers and oscillographs which record up to six variables simultaneously and permit rapid analysis of complex measurements.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle **570** on inquiry card.

X-Y Recorder. New 2-page Data Sheet E-ND46(1) describes maker's "Speedomax" recorder for automatically plotting X vs. Y. Includes optional ranges and features.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **571** on inquiry card.

Recording Systems. New 8-page issue of "The Right Angle" describes maker's "150 Series" six- and eight-channel oscillographic recording systems; also article on "Measurements with the Log-Audio Preamplifier."—Sanborn Co., Cambridge 39, Mass.

Circle **572** on inquiry card.

Data Recorder. New 2-page Bulletin 4-CA presents maker's recorder that features intermittent discrete-step chart motion to give multichannel operation at rates of 10 per second. 2-page Bulletin 4-AA presents use of recorder as resistance comparator for production quality control.—Barnes Development Co., 213 W. Baltimore Pike, Lansdowne, Pa.

Circle **573** on inquiry card.

Inkless Recorders. New 4-page Bulletin RO-2670 describes and illustrates maker's 1-30 channel inkless recorders, for accurate determination of the time, sequence and duration of industrial processes, machine operations, and other automation applications.—Lar-

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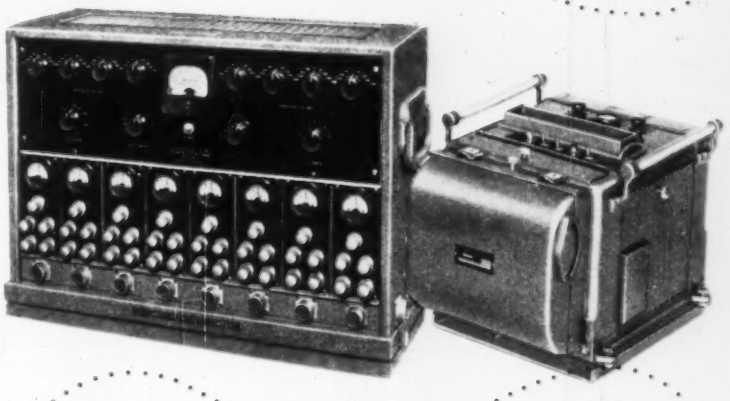

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MANUFACTURERS' NEW LITERATURE

son Instrument Co., 24 Orchard St., Tarrytown, N. Y.

Circle **574** on inquiry card.

Photocopying. New 2-page Bulletin P385 describes and illustrates maker's "Rotoflo" which prepares photocopies of records up to 14 in. wide, of any length, giving positive prints in less than a minute.—Remington Rand, Inc., 315 Fourth Ave., New York 10, N. Y.

Circle **575** on inquiry card.

Production Recorder. New 4-page Bulletin 117 describes and illustrates maker's "Productograph" recorder which automatically records stops and starts in production on printed tape.—Simplex Time Recorder Co., Gardner, Mass.

Circle **576** on inquiry card.

Recording Camera. New 4-page bulletin describes maker's "Siemens" 16 mm. recording camera for automatic and remote photographic recording.—Ercona Corp., 527 Fifth Ave., N. Y. 17, N. Y.

Circle **577** on inquiry card.

Magnetic-tape Data Recorder. New 4-page Bulletin DS-3-1-4 describes and illustrates maker's "Model 309" dual-channel data recorder designed for missile test facilities, and applications where data is telemetered to the recorder.—Ampex Corp., 934 Charter St., Redwood City, Calif.

Circle **578** on inquiry card.

Graphic Recorder. New 8-page booklet describes and illustrates maker's "Fact-Finder" 2-channel graphic recorder used for counting, machine production time, test studies, etc.—Alden Research Center, Washington St., Westboro, Mass.

Circle **579** on inquiry card.

COUNTERS, DIGITIZERS

Analog-digital Converter. New 4-page Bulletin 104-1 describes and illustrates maker's "Teleducer" for converting analog voltages into decimal digits which can be relayed to line printers, card punches or other digital recording devices.—Telecomputing Corp., Burbank, Calif.

Circle **580** on inquiry card.

Digital Instruments. New 4-page bulletin describes and illustrates maker's instruments for automatic counting, recording and control including digital cycling counter, time interval meter, counter-timer, preset counter and recording unit model.—Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.

Circle **581** on inquiry card.

Counters. New 4-page descriptive Bulletin 32 illustrates maker's "Micro Meter" small die-cast counters for registering revolutions, strokes, etc.—Durant Manufacturing Co., 1929 North Buffum St., Milwaukee 1, Wis.

Circle **582** on inquiry card.

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Mechanical Counter. New 2-page Bulletin 550-1054 describes maker's "Model 550 Rayconter" with speeds up to 3,000 per minute.—Raycon Corp., 826 Willow St., Redwood City, Calif.

Circle **583** on inquiry card.

SPEED, FREQUENCY

Tachometers. New 2-page Bulletin 770-B describes and illustrates maker's dwarf-type "Standco" vibrating-reed tachometers and stationary-type vibrating-reed tachometers.—Herman H. Sticht Co., Inc., 27 Park Place, N. Y. 7, N. Y.

Circle **584** on inquiry card.

Frequency Meter. New 2-page Bulletin 623 E describes and illustrates maker's two-reed frequency-meter for determining mechanical vibrations, electrical oscillations, revolutions, and torsional vibrations.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

Circle **585** on inquiry card.

STRAIN, TORQUE

Strain Oscillograph. New 12-page issue of Hathaway Engineering News (Vol. 4, No. 4) describes maker's "Type S20-B" aircraft oscillograph for recording of strain, vibration, flight values, etc.; and "Type RS-20" portable strain indicator for accurate static-strain measurements.—Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.

Circle **586** on inquiry card.

Displacement, Strain Measurement. Two new 2-page bulletins describe maker's new "Type 324" cathode-ray oscillographs for d-c. measurements in the millivolt and microvolt region, and applications with "Type 335" strain gage control and with differential transformers for direct measurement of strain and displacement.—Allen B. DuMont Labs., Inc., Clifton, N. J.

Circle **587** on inquiry card.

Torquemeter. New 12-page Bulletin 4308 presents description on maker's "SR-4" torquemeter which translates torsion into changes in electrical energy, and presents a complete line of precision pickups.—Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

Circle **588** on inquiry card.

Stress Analyzer. New 4-page illustrated leaflet describes maker's "Androscope" x-ray diffraction stress analyzer for determining magnitude and sense of residual stresses.—Holger Andreasen, Inc., 703 Market St., San Francisco 3, Calif.

Circle **589** on inquiry card.

Torque Testing. New 4-page Bulletin TTF-53 describes and illustrates maker's torque-testing fixtures for determining ultimate strength of screws or threaded connections and to apply proof loads.—P. A. Sturtevant Co., Addison, Ill.

Circle **590** on inquiry card.

Tension Meter. New 2-page bulletin describes maker's "Saxl" tension meter for measuring tension of filamentous materials.—Tensitorn, Inc., Harvard, Mass.

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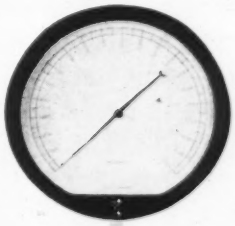

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NEW LITERATURE

MOTION, VIBRATION

Differential-transformer Amplifier. New 2-page bulletin describes maker's "Model 400" differential-transformer amplifier for dynamic study of physical phenomena.—Daytronic Corp., 215 S. Main St., Dayton, Ohio.
Circle **592** on inquiry card.

Stroboscopic Vibration Equipment. New 2-page bulletin describes maker's "Model 102 Slip-Sync" frequency modifier for synchronizing stroboscopic equipment in studying equipment subjected to vibrations.—Chadwick-Helmuth Co., P. O. Box 321, Monrovia, Calif.
Circle **593** on inquiry card.

Position Indicators. New 2-page Product Sheet 125 describes and illustrates maker's miniaturized remote position indicator for aircraft applications on cowl flaps, nose wheels, landing gear, etc.—Avien Co., 58-15 Northern Blvd., Woodside 77, N. Y.
Circle **594** on inquiry card.

GAGING

Indicating Micrometer. New 2-page bulletin describes and illustrates maker's "Master Compar" indicating micrometer and comparator for inspection of mass-produced parts, screw-machine products, ground pieces, etc. —George Scherr Co., Inc., 200 Lafayette St., N. Y. 12, N. Y.
Circle **595** on inquiry card.

Bevelgage. New 2-page Bulletin 543 describe maker's "Gemo" bevelgage for setting and checking angles within 1 minute of arc in toolrooms and inspection departments.—Cleveland Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.
Circle **596** on inquiry card.

Optical Comparator. New 4-page folder describes maker's duplex shadowgraph comparator used next to machines, on production or assembly line, inspection department, etc.—Portman Instrument Co., Inc., Town Dock Rd., New Rochelle, N. Y.
Circle **597** on inquiry card.

Screw Testing. New 2-page bulletin lists maker's screw testing accessories designed for Sturtevant Torque testing fixtures "Models TTF-¼ and TTF-½" for testing machine and tapping screws.—Tools, Inc., 1733-37 N. 25th Ave., Melrose Park, Ill.
Circle **598** on inquiry card.

Taper Measuring. Two new 2-page Bulletins describes maker's "Taper-Mike" for measuring taper without removing work piece from machine.—Taper Micrometer Corp., 100 Grove St., Worcester, Mass.
Circle **599** on inquiry card.

TESTING

Environmental Test Equipment. New 8-page bulletin describes and illustrates maker's line of environmental test equipment including temperature,

altitude and humidity test cabinets; sand and dust machines; calibration chambers; low temperature dry ice cabinets; compensation test baths; walk-in rooms; and explosion chambers.—International Radiant Corp., 40 Matinecock Ave., Port Washington, N. Y.

Circle **600** on inquiry card.

Insulation Tester. New 24-page Bulletin 21-20 describes and illustrates maker's "Megger" high-range, direct-reading ohmmeter for measuring electrical insulation resistance, determining presence of moisture, etc.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

Circle **601** on inquiry card.

Insulation Tester. New 4-page folder describes and illustrates maker's continuous insulation tester for counting and recording pinholes on wire automatically and accurately at wire speeds up to 600 ft. per min.—Peschel Electronics, Inc., 13 Garden St., New Rochelle, N. Y.

Circle **602** on inquiry card.

Hardness Tester. New 2-page Bulletin KE 1154 describes maker's "Color-Glance" Brinell hardness tester which makes possible high-speed production testing and complete automatic operation. Steel City Machines, Inc., 8817 Lyndon Ave., Detroit 38, Mich.

Circle **603** on inquiry card.

Soil-test Equipment. New 104-page 1955 Catalog presents descriptions and illustrations on over 1250 items of apparatus for engineering tests of soils, concrete, asphalt and construction materials. Includes suggested laboratory layouts with equipment lists.—Soiltest, Inc., 4520 W. North Ave., Chicago 39, Ill.

Circle **604** on inquiry card.

Overpotential Testing. New 28-page brochure "Resume of DC Overpotential Testing" discusses techniques and principles involved, and a bibliography of material on testing technique.—Beta Electric Corp., 333 E. 103 St., New York 29, N. Y.

Circle **605** on inquiry card.

Spring Tester. New 4-page bulletin describes and illustrates maker's spring tester for testing tension, compression and determine correct loads, tolerances, and gradients for springs.—Pennsylvania Scale Co., Bareville, Pa.

Circle **606** on inquiry card.

Testing Laboratory. New 4-page bulletin presents facilities and services offered by electrical-component-testing laboratory.—Rototest Laboratories, 2803 Los Flores Blvd., Lynwood, Calif.

Circle **607** on inquiry card.

Cathodic Etching Apparatus. Two new 2-page data sheets describe maker's cathodic etching apparatus which makes it possible to cathodically etch metal specimens for inspection by light or electron microscopy. Accompanying sheet covers maker's carbon evaporation apparatus.—Optical Film Engineering Co., 2731-37 North Sixth St., Philadelphia 33, Pa.

Circle **608** on inquiry card.

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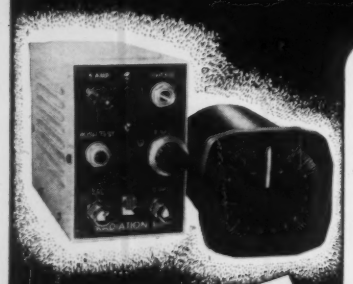

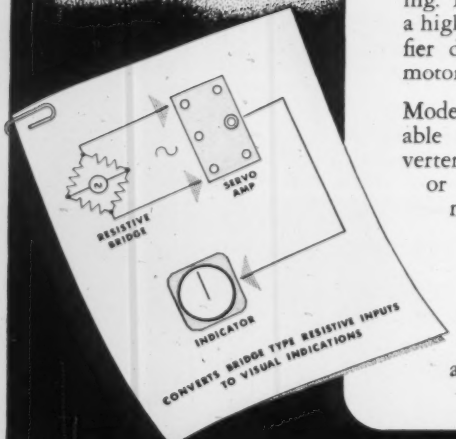

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NEW LITERATURE

OPTICAL

Solar Ephemeris. New 96-page 1955 edition of "Gurley Ephemeris" presents definitions, descriptions, examples and tables for determining true azimuth from observations of the sun, polaris, or other stars.—W. & L. E. Gurley, Troy, N. Y.

Circle **609** on inquiry card.

Optical Instruments. New 4-page illustrated brochure 544-54 describes maker's "Zirconium" concentrated-arc lamp for microscope illumination, 25-watt power supply, lens collimating unit, etc.—Burton Mfg. Co., 11201 W. Pico Blvd., Los Angeles 64, Calif.

Circle **610** on inquiry card.

ITV, Picture Monitors. New set of bulletins describe maker's "Private Eye" monitors for broadcasting and closed-circuit TV, including studio control-room selection, film projection preview, etc.—Television Utilities Corp., 1315 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle **611** on inquiry card.

LAB APPARATUS

Laboratory Press. New set of 4-page Bulletins CLP and 159 describe maker's laboratory press (for industrial and research applications) and wet-film applicators for testing and comparing paints, inks, etc.—Gardner Laboratory, Inc., Bethesda 14, Md.

Circle **612** on inquiry card.

Laboratory Instruments. New 8-page issue of "Newsletter" (Vol. 2, No. 8) describes and illustrates maker's "Quickie" high-speed ball mill for checking pigments and inerts from various suppliers, synchronous electric timers, "Labelon" plastic labeling tape, microcard reader, pipe surface thermometer, and temperature regulator for experimental and laboratory use. —Gardner Laboratory, Inc., Bethesda 14, Md.

Circle **613** on inquiry card.

Laboratory Apparatus. New 16-page brochure describes maker's Mini-Lab" assemblies and components for small-scale laboratory work.—Ace Glass, Inc., Vineland, N. J.

Circle **614** on inquiry card.

Flash Tester. New illustrated 8-page Bulletin 720 describes maker's automatic loading-rack flash-point-tester for checking distillate fuel at any bulk distributing or storage point. —Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **615** on inquiry card.

Infrared Bath. New 10-page folder describes and illustrates maker's universal infrared bath with temperature control within 0.001 C. from 0 to 60 C.; high accuracy achieved by use of infrared heater.—Kinetic Instrument Co., 3250 Skokie Valley Rd., Highland Park, Ill.

Circle **616** on inquiry card.

Carbon Residue Apparatus. New 2-page Data Sheet 11314 describes and

illustrates maker's "Ramsbottom" carbon residue apparatus for determining amount of carbon residue left after evaporation and pyrolysis of an oil.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **617** on inquiry card.

Laboratory Apparatus. New 8-page Bulletin 19 presents, describes and illustrates maker's safe vacuum oven, "Forma-Stir" utility stirrers, low-temperature and variable-refrigerated water bath, soft-top hot plate, etc.—Forma Scientific, Inc., Box 332, Marietta, Ohio.

Circle **618** on inquiry card.

ANALYTICAL

pH, Redox. New 2-page Data Sheet ND42-96(1) describes and illustrates maker's panel-mounted indicator for pH and redox measurement.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

Circle **619** on inquiry card

Spectrography. New 4-page issue of "JACO News Letter" (Vol. 1, No. 4), features article on "Precision of The JACO Spark Source With The Spark-Lock."—Jarrell-Ash Co., 26 Farwell St., Newtonville, Mass.

Circle **620** on inquiry card.

Spectrography. New 2-page issue of "JACO News Letter" (Vol. 1, No. 5) features article on "Determination of Boron in Steel with a 1½ Meter Spectrograph."—Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle **621** on inquiry card.

Gas Analyzers. New 2-page Bulletin IP describes maker's gas-purity analyzers with flow and pressure regulator, filter drier, and power supply control unit with voltage regulator.—Gow-Mac Instrument Co., 100 Kings Rd., N. J.

Circle **622** on inquiry card.

Indexing Spectrometer. New 4-page bulletin "Norelco Autrometer" describes and illustrates maker's "Autrometer" automatic multi-element indexing spectrometer for process control featuring printout of twelve elements.—Mount Vernon Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle **623** on inquiry card.

Spectrographic Electrodes. New 24-page catalog describes and illustrates maker's line of spectroscopic graphite products, including disc-type, "Scribner Type," etc.—United Carbon Products Co., Inc., 1st and N. Madison Sts., Bay City, Mich.

Circle **624** on inquiry card.

Gas Analyzer. New 12-page Booklet 82 presents principles and applications of maker's "Fracton" for the analysis of light hydrocarbon gases.—Burrell Corp., 2223 Fifth Ave., Pgh. 19, Pa.

Circle **625** on inquiry card.

Photometer. New 8-page Bulletin 231 describes and illustrates maker's "Model 21" flame photometer for precise measurement in analysis of low concentrations of Na, K, Ca and other

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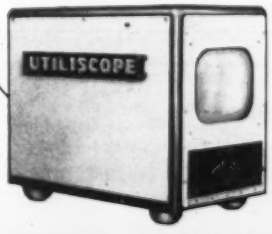

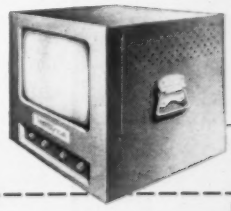

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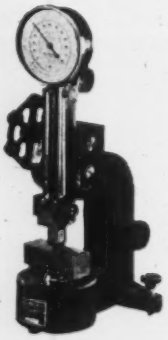

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Answers to I.Q. Quiz on page 300

1.—b	9.—d	17.—b
2.—a	10.—c	18.—b
3.—b	11.—d	19.—a
4.—c	12.—a	20.—c
5.—a	13.—b	21.—b
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NEW LITERATURE

elements.—Coleman Instruments, Inc., 318 Madison St., Maywood, Ill.

Circle **626** on inquiry card.

Spectrophotometers. New 16-page Bulletin SB1-104-2M describes maker's "Cary" spectrophotometers (for rapid recording of spectra with good resolving power and high photometric accuracy), infrared and ultraviolet analyzer, Raman spectrograph and electrometers.—Applied Physics Corp., 362 W. Colorado St., Pasadena, Calif.

Circle **627** on inquiry card.

ELECTRONIC, ELECTRICAL INSTRUMENTS

Electronic Test Instruments. New 16-page Catalog 546 describes maker's laboratory testing instruments, low-frequency "Q" indicator, comparison and limit bridges, null detector and vacuum tube voltmeter, decade amplifiers, inductors, capacitors, megohmmeters, filters, etc.—Freed Transformer Co., Inc., 1718 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.

Circle **628** on inquiry card.

Transducers, Accelerometers. New 8-page bulletin "Products for Industry and Science" describes maker's accelerometers, cathode followers, filters, pressure and blast gages, hydrophones, etc., for applications in shock and vibration measurement, industrial control and noise abatement, guided-missile instrumentation and control, medical instrumentation, etc.—Gulton Industries, Inc., Metuchen, N. J.

Circle **629** on inquiry card.

Electronic Test Instruments. New 4-page Bulletin 25M describes maker's frequency meters, frequency interpolators and multipliers, standard ratio transformers, peak-reading wide-band pulse voltmeters and filters.—Gertsch Products, Inc., 11846-48 Mississippi Ave., Los Angeles 25, Calif.

Circle **630** on inquiry card.

Resistance Filter. New 2-page bulletin describes maker's "Type 502" "Twin-T" resistance-capacitance filter networks for frequency-sensitive circuit applications.—White Instrument Laboratories, 203 Riverside Drive, Austin 4, Texas.

Circle **631** on inquiry card.

Hi-Fi Systems. New 16-page Booklet "This Is High Fidelity" describes high-fidelity reproduction of voice and music, explains functions of basic units used in home high-fidelity music systems.—Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

Circle **632** on inquiry card.

Megohmmeter. New 4-page Form 873-A presents maker's Type 1862-B Megohmmeter for measuring up to 2,000,000 megohms.—General Radio Co., Cambridge 39, Mass.

Circle **633** on inquiry card.

Panel Indicators. New 8-page issue (Vol. 21, No. 10) of "Electrical Measurements" describes maker's line of panel instruments for current and volt-

age, with accuracies as high as 0.25 percent.—Sensitive Research Instrument Corp., Mount Vernon, N. Y.

Circle **634** on inquiry card.

Electronic Test Equipment. New 4-page leaflet describes and illustrates maker's line of electronic test equipment—r-f. signal generator, oscilloscopes, tube tester, VTVM, etc.—Electronic Measurements Corp., 280 Lafayette St., New York 12, N. Y.

Circle **635** on inquiry card.

Reflectometers. New 8-page issue of "The Hewlett-Packard Journal" (Vol. 6, No. 1-2) features article on "The -hp- Microwave Reflectometers."—Hewlett-Packard Co., 275 Page Mill Rd., Palto Alto, Calif.

Circle **636** on inquiry card.

Static Electricity. New 2-page Bulletin TSB-1 describes static electricity and dust control on plastics. Includes Product Data Sheet giving specifications, uses, and applications of "Logostat R-2154."—Logo, Inc., 13799 S. Avenue "O", Chicago 33, Ill.

Circle **637** on inquiry card.

Power Test Sets. New 4-page bulletin describes and illustrates maker's analyzers and accessories for electrical power testing.—Niagara Electrical Instrument Co., 559 Ellicott St., Buffalo 3, N. Y.

Circle **638** on inquiry card.

Panel Voltmeters. New 4-page illustrated bulletin describes maker's d-c. and a-c. expanded-scale panel voltmeters. Includes tables giving base voltages, spans and accuracy.—Arga Div., Beckman Instruments, Inc., 220 Pasadena Ave., South Pasadena, Calif.

Circle **639** on inquiry card.

VTVM, Power Supplies. Four new 2-page Engineering Bulletins VM-100, VM-101A, VM-102, and VM-103 describe maker's line of miniature, panel-mounting, vacuum-tube voltmeters and auxiliary power supplies.—Trio Labs., Inc., 3293 Seaford Ave., Wantagh, N. Y.

Circle **640** on inquiry card.

Linear Amplifier. New 4-page Brochure DA5 describes maker's linear amplifier for spectrometry applications in general laboratory work with ionization chambers, proportional or scintillation counters.—Detectolab, Inc., 6544 N. Sheridan Rd., Chicago 26, Ill.

Circle **641** on inquiry card.

Diode Tester. New 2-page Bulletin 120 describes and illustrates maker's germanium-diode tester "Model 110A" for field and laboratory.—Empire State Laboratories, Inc., 2608 Merrick Rd., Bellmore, N. Y.

Circle **642** on inquiry card.

POWER SOURCES

Line-voltage Regulators. New 4-page Bulletin 874-A presents Type 1570-A line-voltage regulators that use servomechanism-positioned Variacs to control voltage.—General Radio Co., Cambridge 39, Mass.

Circle **643** on inquiry card.

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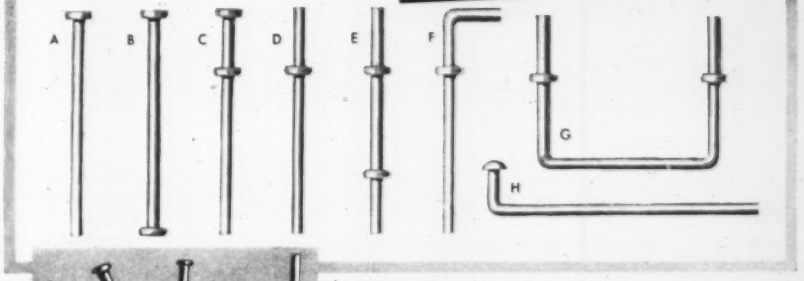

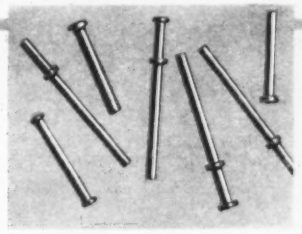

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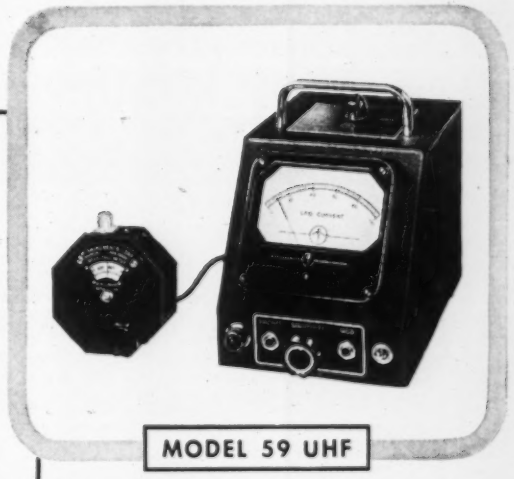

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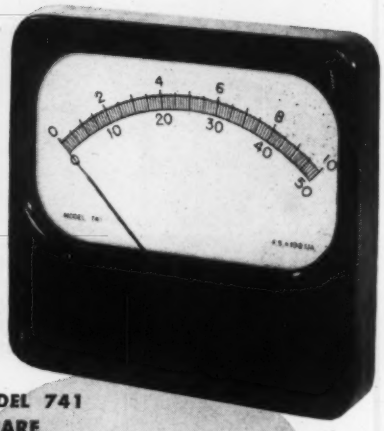

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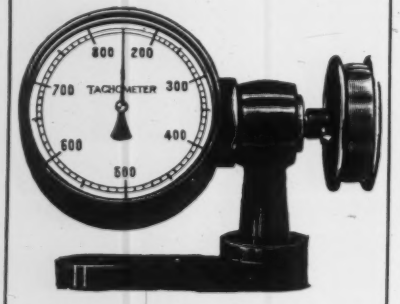

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NEW LITERATURE

Voltage Regulator. New 8-page leaflet describes maker's "Type 1101" rheostat-generator voltage regulator for precise voltage regulation of 400-cycle generators with exciter.—Regulator Equipment Corp., Paterson, N. J.
Circle **644** on inquiry card.

Voltage Source, Comparator. New 2-page data sheet describes maker's "Model 50" variable-voltage source and voltage comparator for analog computer and general laboratory applications.—Donner Scientific Co., 2829 7th St., Berkeley 10, Calif.
Circle **645** on inquiry card.

Power Supplies. New 28-page Catalog 155 lists maker's complete 1955 line of dynamotor power supplies.—Carter Motor Co., 2644 N. Maplewood Ave., Chicago 47, Ill.
Circle **646** on inquiry card.

Power Supplies. New 2-page data sheet describes and illustrates maker's tubeless power, high-current, and dual transistor supplies.—Electronic Research Associates, Inc., Box 29, Caldwell, N. J.
Circle **647** on inquiry card.

Power Supply. New 2-page bulletin describes maker's "Model 201" instrument power supply designed as a regulated d-c. source for strain gages, potentiometers and resistance networks.—White Instruments Laboratories, 203 Riverside Drive, Austin 4, Texas.
Circle **648** on inquiry card.

Power Supplies. New 2-page specification sheet describes maker's "Model 2" electronically-regulated, d-c. constant-voltage power supplies with voltage from 200 to 325 volts d-c. for load currents 0 to 100 ma.—Associated Specialties Co., 1751 Main St., Orefield, Pa.
Circle **649** on inquiry card.

Aircraft Power Supplies, Test Equipment. New 8-page Booklet CDG 5991 describes and illustrates maker's ground-support power equipment, pneumatic power supplies, cabin pressurization testers, test stands, etc.—Electroflow, Inc., Equipment Div., American Electronics, Inc., 2112 Chico Ave., El Monte, Calif.
Circle **650** on inquiry card.

RESISTORS, POTENTIOMETERS

Resistors. New 2-page Oct.-Nov. 1954 issue of "Ohmite News" features articles on "Amrecon" relays and "Ohmite" rheostat assemblies solving difficult control problems.—Ohmite Manufacturing Co., 3603 Howard St., Skokie, Ill.
Circle **651** on inquiry card.

Resistance Units. New 2-page Data Sheet 54-86 describes maker's "Series T-1-A" precision resistance units for use as potentiometers or rheostats in experimental circuits.—Helipot Corp., 916 Meridan Ave., S. Pasadena, Calif.
Circle **652** on inquiry card.

Potentiometers. New 2-page bulletin presents specifications on foreign made "Multipot H4 Telepot" and "Models E and ET" miniature precision potentiometer.—F. H. Paul & Stein Bros., Inc., 235 Fifth Ave., New York 16, N. Y.

Circle **653** on inquiry card.

Potentiometers. New 8-page leaflet describes maker's line of linear and nonlinear potentiometers for generating sine or consine functions; also toroidal potentiometers.—Gamewell Co., Newton Upper Falls 64, Mass.

Circle **654** on inquiry card.

SWITCHES, RELAYS

Precision Switches. New 28-page Catalog 62 lists maker's complete line of precision snap-action basic switches, auxiliary actuators and terminal enclosures. Includes photographs, drawings, terminal variations, and electrical ratings.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **655** on inquiry card.

Industrial Solenoids. New 16-page four-color Bulletin GEA-6215 describes maker's complete line of strongbox industrial solenoids. Presents information on product features, laboratory test, force and current curves, and dimensions for both push and pull types.—General Electric Co., Schenectady 5, N. Y.

Circle **656** on inquiry card.

Switches, Timers. New 32-page looseleaf catalog presents maker's automatic control equipment including transfer, remote control, and automatic time switches; automatic reset, interval, process, and impulse timers; magnetic contactors; program clocks; and reversing starters.—Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill.

Circle **657** on inquiry card.

Stepping Relays, Circuit Timing. Four new 2-page Bulletins 1, 2, 4, and 6, titled "Ledex Engineering Sketchbook," presents information on applications of rotary solenoids and stepping relays in transceivers, scoreboards, etc.—G. H. Leland, Inc., Dayton 2, Ohio.

Circle **658** on inquiry card.

Relays. New 2-page Publication Sheet 553 "Relay Selection Tabulations" describe maker's magnetically-held relays. Includes diagrams for two wire control, stop-start 3-wire maintained control, and thermostatic control for magnetically-held relays.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **659** on inquiry card.

Subminiature Switches. Two new bulletins Form 84-139 and Form 84-141 describe maker's environment-proof, subminiature precision switches "1SE1(SPDT), 1SE2(SPST), and 1SE3(SPST)."—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **660** on inquiry card.

Oil-Tight Push Buttons. New 16-page Bulletin GEA-5779B describes maker's complete line of oil-tight push

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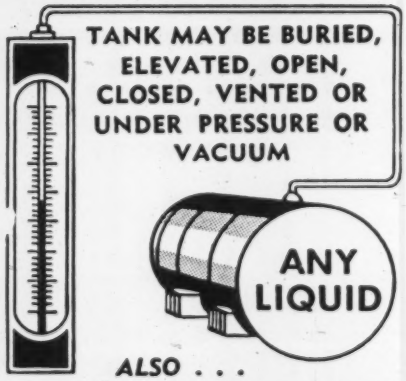

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NEW LITERATURE

buttons, selector switches, and accessories.—General Electric Co., Schenectady 5, N. Y.

Circle **661** on inquiry card.

Time-Delay Relays. New 2-page Bulletin TD500 describes maker's time-delay relays for applications requiring close-tolerance time-delay functions.—A. W. Haydon Co., Waterbury, Conn.

Circle **662** on inquiry card.

Counterpoised Relay. New 2-page issue of "Diaphlex Newsletter" (Vol. 1, No. 26) describes and illustrates maker's subminiature counterpoised relay—capable of withstanding shock of 100 g's.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Circle **663** on inquiry card.

Pilot Relay. New 2-page data sheet describes and illustrates maker's "Model EB" electronic pilot relay for controlling large values of current and power with signal current of 2 microamperes.—Industrial Electronic Controls Co., 2271 E. 14th St., Brooklyn 29, N. Y.

Circle **664** on inquiry card.

ELECTRONIC COMPONENTS

Transistors. New 2-page bulletin describes maker's silicon transistors and junction diodes.—Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Texas.

Circle **665** on inquiry card.

Germanium Diodes. New 8-page Bulletin SP2A describes maker's germanium diodes and point-contact crystal rectifiers.—Hughes Aircraft Co., Culver City, Calif.

Circle **666** on inquiry card.

Toroid Transformers. New 2-page illustrated bulletin describes maker's miniature toroid transformers for applications requiring a compact, multiwinding transformer, operating at low level and in low-impedance circuits over a wide frequency range.—Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.

Circle **667** on inquiry card.

Terminal Blocks. New 4-page Bulletin PB describes and illustrate maker's heavy-duty sectional "pres-SURE-block" terminal blocks—2-page Bulletin PBS describes block that features hand assembly and disassembly.—Buchanan Electrical Products Corp., Hillside, N. J.

Circle **668** on inquiry card.

RF Connectors. New 8-page issue of "AMPHENOL Engineering News" (Vol. 7, No. 7), features articles on "Subminax RF Connectors", and "New Edison Temperature Monitoring System."—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle **669** on inquiry card.

Pilot Lights. New 4-page Brochure L-157 describes maker's subminiature

pilot lights for grounded circuits.—Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

Circle **670** on inquiry card.

Transformers. New 24-page Catalog 545 describes maker's input, interstage and driver transformers; toroidal inductors; magnetic amplifiers; auto transformers; etc.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.

Circle **671** on inquiry card.

Graphic-circuit Connectors. New 4-page bulletin describes and illustrates maker's graphic-circuit connectors with compression-loaded contact, ribbon contacts, and open-ended construction.—Circon Component Co., 17544 Raymer St., Northridge, Calif.

Circle **672** on inquiry card.

Coaxial Connector. New 8-page issue of "General Radio Experimenter" Vol. 29, No. 7, features article on improved slotted line that increases accuracy and convenience of coaxial line measurements.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **673** on inquiry card.

Delay Lines. New 2-page Data Sheet 54-81 presenting construction, specifications and applications on maker's "Helidel" delay lines.—Helipot Corp., 916 Meridian Ave., South Pasadena, Calif.

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Delay Lines. New 5-page Data Sheet 29 describes maker's military-type and subminiature-type (A1557) delay lines for use in a line that requires ruggedness and unusual compactness.—Jacobs Instrument Co., Bethesda, Md.

Circle **675** on inquiry card.

Microphone Cables. New 8-page bulletin describes maker's shielded wire and cable for microphone and sound system use, and speech input and sound-system cables with enamel-textile insulation and polyvinyl-chloride-insulated signal wires.—Whitney Blake Co., New Haven 14, Conn.

Circle **676** on inquiry card.

Magnetic Cores. New 4-page bulletin presents specifications and data on maker's ferramic "Q" magnetic cores.—General Ceramics Corp., Keasbey, N. J.

Circle **677** on inquiry card.

Coil Forms. New 12-page booklet "Arbor List" covers specifications of over 2000 coil forms in all shapes, sizes, I.D.'s and O.D.'s. Includes technical data.—Precision Paper Tube Co., 2035 W. Charleston St., Chicago 47, Ill.

Circle **678** on inquiry card.

Capacitors. New 4-page Bulletin 154 describes maker's plastic film capacitors hermetically sealed in metal cases.—Electronic Fabricators, Inc., 682 Broadway, New York 12, N. Y.

Circle **679** on inquiry card.

Pilot-light Assemblies. New 19-page Catalog 9P describes maker's dial and jewel pilot-light assemblies

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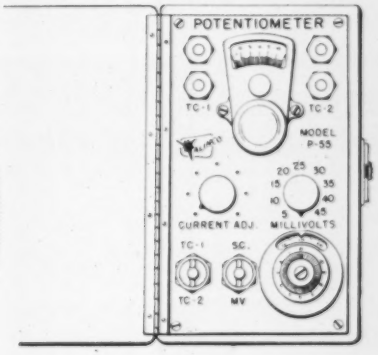

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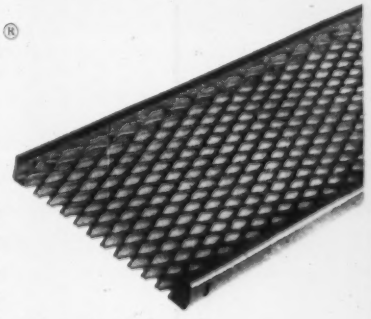

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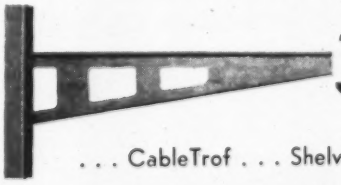

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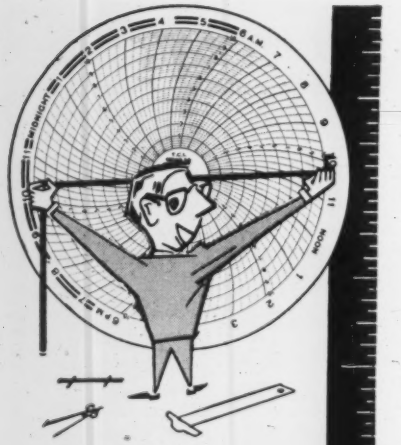

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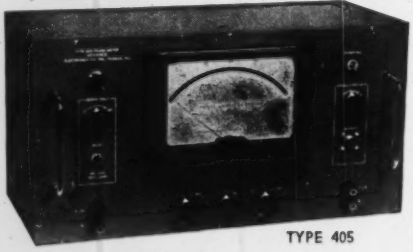

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NEW LITERATURE

including built-in resistors for neon glow lamps.—Drake Mfg. Co., 1713 W. Hubbard St., Chicago 22, Ill.
Circle **680** on inquiry card.

Microphones. New 4-page bulletin describes maker's dynamic non-directional microphone "DM-1060" and omnidirectional dynamic studio microphone "DM 2050."—Frank L. Capps & Co., Inc., 20 Addison Place, Valley Stream, N. Y.
Circle **681** on inquiry card.

Transformers. New 32-page Catalog CT-554 presents maker's complete line of audio filters, autotransformers, filter reactors, chokes, bias, control, driver, filament, plate transformers, etc.—Chicago Standard Transformer Corp., Addison & Elston, Chicago 18, Ill.
Circle **682** on inquiry card.

Distribution Transformers. New 8-page Bulletin 61B7309B describes maker's protected distribution transformers available in ratings of 3 through 100 kva, 2400 to 14,400 volts. —Allis-Chalmers Mfg. Co., 942 S. 70th St., Milwaukee, Wis.
Circle **683** on inquiry card.

MECHANICAL COMPONENTS

Micro Bearings. New 4-page issue of "New Hampshire Scene" (No. 45, Jan., 1955) presents description on maker's micro bearings "5412MC and FR4ZC." —New Hampshire Ball Bearings, Inc., Peterborough 1, N. H.
Circle **684** on inquiry card.

Miniature Bearings. New 2-page Bearing Specification Performance Guide 5434 is aid in organizing design information on miniature bearings.—Miniature Precision Bearings, Inc., Keene, N. H.
Circle **685** on inquiry card.

Instrument Gears. New 8-page leaflet describes and illustrates maker's precision instrument gears. Includes 3 two-page data sheets on stock and fine-pitch gears.—Dexter Machine Products, Inc., Chelsea, Mich.
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Instrument Gears. New 6-page brochure describes and illustrates maker's precision instrument gears.—Geartronics Div., Technical Products Co., Inc., West Concord, Mass.
Circle **687** on inquiry card.

Titanium Tubing. New 8-page Bulletin 43 presents information on fabrication of unalloyed titanium tubing. Includes aircraft applications, an absorption tube used on a microanalytical train, autoclave cooling coils, etc.—Superior Tube Co., 1564 Germantown Pike, Norristown, Pa.
Circle **688** on inquiry card.

Brackets, Clamps. New 60-page Engineering Manual 201G presents data on maker's complete line of clamps, brackets, and shims used for aircraft,

electronics and industrial applications. —Thomas Associates, 4607 Alger Street, Los Angeles 39, Calif.

Circle **689** on inquiry card.

Name Plates. New 4-page bulletin "How to Stamp Name Plates" illustrates maker's stamping machines and etched name plates.—Acromark Co., 9-13 Morrell St., Elizabeth, N. J.

Circle **690** on inquiry card.

MATERIALS

Vacuum Melted Metals. New 17-page Technical Bulletin VM 100 describes maker's new vacuum-melted metals and alloys. Includes details and characteristics on physical properties of the newly-developed alloys "M-252 and 1570", and a 2-page Technical Data Sheet HV-4 on "Hevimet" hi-tensile metal.—Carboloy Dept., General Electric Co., Box 237, Roosevelt Park P.O., Detroit 32, Mich.

Circle **691** on inquiry card.

Cemented Carbide. New 24-page Booklet GT-191A "Selection of Carboloy Grades and Suggested Speeds" presents data for determining efficient cutting speeds for machining steel, cast iron and nonferrous materials.—Carboloy Dept., General Electric Co., Detroit 32, Mich.

Circle **692** on inquiry card.

Zirconium. New 68-page Brochure A-1297 "Facts About Zirconium" describes and illustrates maker's metal zirconium for atomic energy applications in chemical and metallurgical fields.—Carborundum Metals Co., Inc., Akron, N. Y.

Circle **693** on inquiry card.

FABRICATION

Engraving Machine. New set of bulletins (B-1, 3D-5, List 101, R-11-53) describe and illustrate maker's "Model 3D-5" engraving machine and accessories for cutting steel stamps, dies, and designs in metal, wood, etc.—H. P. Preis Engraving Machine Co., 651 U. S. Highway 29, Hillside 5, N. J.

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Metal Products. New 4-page Bulletin 142 illustrates maker's custom-built metal products, instrument panels, chassis frames, aluminum cubicles, and control cabinets.—Falstrom Co., 98 Falstrom Court, Passaic, N. J.

Circle **695** on inquiry card.

Soldering Oven. New 2-page bulletin presents description of maker's "Model 3300" soldering oven for automatic soldering production, available in five conveyor speeds.—Electrical Industries Div., Amperex Electronic Corp., 44 Summer Ave., Newark 4, N. J.

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Vacuum Forming. New 4-page issue of "Marblette Mirror" features article on plastic fabrication method used to produce three-dimensional displays, instrument panels, etc.—Marblette Corp., 37-21 Thirtieth St., L. I. C. 1, N. Y.

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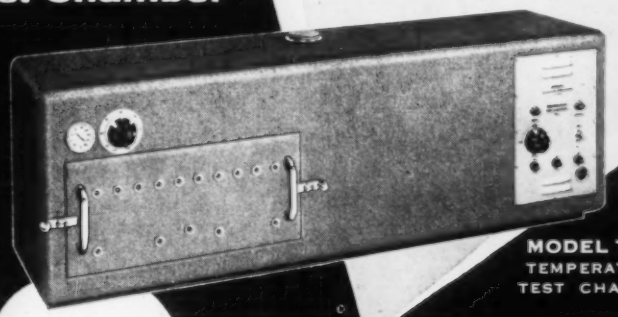

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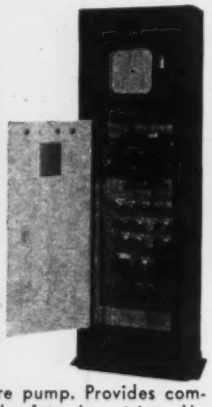

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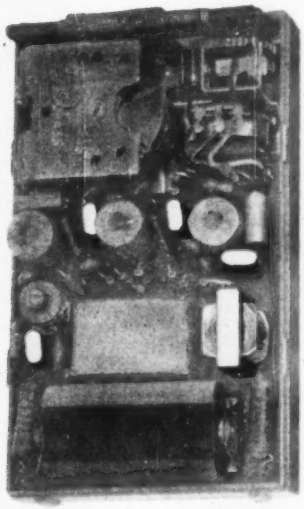

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